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Anxiety and Chronic Couple Relationship Stress Moderate Adrenocortical Response to Couple Interaction in Expectant Parents

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Abstract

The study examines whether anxiety or chronic relationship stress alter the way that couple conflict affects cortisol levels for women and men during the transition to parenthood. Saliva samples, assayed for cortisol, were collected before and after couple interaction from 128 heterosexual couples expecting their first child. Confirming prior research, expectant mothers had higher cortisol levels than their spouses, and gestational age was linked to women's cortisol level. Negativity during couple interaction was associated with greater cortisol reactivity for men, but not women. Tests of moderation indicated little relation between negativity and cortisol recovery for individuals with a low level of anxiety or little history of chronic arguing with the partner. However, among individuals with elevated levels of either of these two factors, negativity was linked to less cortisol recovery for men but more cortisol recovery for women. Consistent results were also found for the relation between low warmth in the couple interaction and both reactivity and recovery for men and women high in anxiety. Future research should examine whether pregnancy is responsible for these different gender patterns, or whether the inhibition of negativity is stressful for women with high levels of risk.

Keywords

Cortisol; Couple Interaction; Couple Relations; HPA axis; Pregnancy; Stress

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Substantial evidence suggests that both acute and chronic stress are linked to poor health (Cohen, Janicki-Deverts, & Miller, 2007). Stress-related biological systems such as the hypothalamic-pituitary-adrenal (HPA) axis and balance between the branches of the autonomic nervous system may be partly responsible for links between stress and health problems (Hellhammer & Hellhammer, 2008). For example, stress may lead to dysfunction in the HPA system (Matthews, Gump, & Owens, 2001), and such dysfunction that leads to

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elevated levels of cortisol may be linked to negative emotionality, learning/memory deficits, and immuno-suppression (Nelson, 2005). Of particular relevance for intervention efforts is the substantial variability in individuals' psychological and physiological response to stress (author citation removed). Such individual differences may be related individual factors such as maladaptive psychological functioning: several mental health and behavioral problems have been found to affect HPA axis functioning (Susman, 2006). The external environment, such as the existence of chronic stressors, may also lead to individual differences in stress responsivity. For example, repeated triggering of the HPA axis by stressors may have detrimental effects on HPA function (Matthews et al., 2001; Nelson, 2005).

Evidence suggests that close relationships, especially romantic relationships, can play multiple roles in the intersection of stress, physiological response, and health. Stress due to relationship conflict is associated with HPA axis activation and increased cortisol levels. Moreover, chronic or acute stress can undermine the quality of close relationships, leading to both increased interpersonal conflict (Conger, Ge, Elder, & Lorenz, 1994; Krishnakumar & Buehler, 2000) and decreased ability to cope with the stress of conflict (Almeida, McGonagle, Cate, Kessler, & Wethington, 2003). On the other hand, supportiveness in close relationships can protect mental and physical health from stress (Cohen & Lemay, 2007; Kiecolt-Glaser & Newton, 2001).

This paper extends research on health and close relationships by examining links between social interaction and adrenocortical activity in couples during the transition to parenthood, a critical phase in the trajectory of couple relationships. This period is particularly important given recent animal and human research indicating that maternal anxiety and stress alter the fetal milieu (Van den Bergh, Mulder, Mennes, & Glover, 2005). Impacts include largely negative effects on fetal development (Kivlighan, DiPietro, Costigan, & Laudenslager, 2008; Van den Bergh et al., 2005), birth outcomes (Bolten et al., 2011; Field et al., 2010), and infant health and stress regulation (Beijers, Jansen, Riksen-Walraven, & de Weerth, 2010; Davis, Glynn, Waffarn, & Sandman, 2011; Grant et al., 2009; Harris & Seckl, 2011). In this study, our central goal was to assess whether expectant mothers' and fathers' HPA responsivity to couple interaction was moderated by anxiety and chronic relationship stress.

Relationship Conflict and HPA Responsivity

Relationship conflict can engender intense emotions and temporary dysregulation. The concept of dysregulation implies two opponent processes: activation (reactivity) and recovery (down-regulation). The temporal pattern of the psychobiology of the stress response allows for a simple ordering of reactivity and recovery. Generally, the HPA axis response to an acute stressor results in an increase salivary cortisol, peaking after about 20 minutes, with recovery toward baseline occurring over the subsequent 20–40 minutes (Dickerson & Kemeny, 2004).

Most prior physiological research has been framed in terms of reactivity (i.e., comparing a change in cortisol following conflict with a baseline level) or in terms of the diurnal pattern of cortisol production. For instance, levels of stress hormones during the day and especially during conflict differentiated couples who would divorce over the next ten years from stable couples (Kiecolt-Glaser, Bane, Glaser, & Malarkey, 2003). Some studies have found differences between men's and women's physiological reactions to conflict, with wives often more reactive to marital problems (Kiecolt-Glaser & Newton, 2001). Yet this difference has not been found in all reports—some have revealed the opposite pattern (Powers, Pietromonaco, Gunlicks, & Sayer, 2006; Miller, Dopp, Myers, Stevens, & Fahey, 1999).

One possible reason for inconsistent gender difference findings may be a restricted examination of cortisol responsivity. Little work has examined physiological recovery in the couple relationship context, even though recovery may affect the overall impact of a stressor on an individual and on couple relationship dynamics (Powers et al., 2006). An individual's capacity for recovery from stress may contribute to the successful repair of dyadic conflict episodes, facilitating positive relationship quality (Dindia & Baxter, 1987). Repair of conflict episodes may include acknowledging and apologizing for an insult, re-establishing mutual respect, and sharing positive emotions. An individual with a persisting elevated cortisol levels after a stressor—that is, poor recovery—may continue to be physiologically and emotionally aroused, which could interfere with attempts to repair conflict. This is not to say that repair of dyadic conflict is reducible to individual regulatory capacity, as a dyadic relationship has emergent properties that cannot be completely predicted by one individual's functioning. However, individual regulatory or recovery capacity may constrain or set an upper limit on the repair of relationship conflict. Further, relationship conflict may affect men's and women's reactivity and recovery processes differently (Powers et al., 2006).

Not all studies have found high conflict and low warmth to be related to increased cortisol levels (e.g., Fehm-Wolfsdorf, Groth, Kaiser, & Hahlweg, 1999). In one study, positive relationship behaviors moderated the link between negativity and cortisol: Among couples exhibiting little positive behavior, higher negativity was linked to greater increases in cortisol, as expected (Robles, Shaffer, Malarkey, & Kiecolt-Glaser, 2006). But among couples high in positivity, greater negativity was linked to lower levels of cortisol. Such findings suggest that more complex theories and analytic strategies are needed to understand couple conflict, stress, and physiology.

Moderators of the Link between Couple Interaction and HPA Responsivity

Although factors such as anxiety and chronic stress may be associated with altered HPA activity and cortisol levels (e.g., Graeff & Zangrossi, 2010) and thus affect health, we propose that maladaptive psychological functioning and chronic stressors may put an individual at risk by altering physiological responses to adverse stimuli such as partner negativity. In this framework, individual psychological functioning and chronic stress moderate the link between couple conflict and HPA reactivity/recovery, with consequences for relationship dissatisfaction, relationship dissolution, and poor health. This framework is supported by findings from one of the few studies to examine moderation of cortisol responses to interactions with a partner: high levels of cynical hostility accentuated the link between expressed anger and cortisol reactivity (Miller et al., 1999; also see Taylor et al., 2008).

Heuristically, moderation of the link between a stressor and HPA functioning is based on one of several possible mechanisms. Chronic stressors may cause physiological changes in HPA axis reactivity and regulation (Miller, Chen, & Zhou, 2007). Such moderation may also be the result of cognitive-emotional appraisal processes. Individuals with a high degree of anxiety may experience even low levels of couple conflict as threatening; in turn, this distress may promote greater reactivity. Moderation may also result from the impact of chronic stressors on the expression of emotions or emotional behavior (Gross, 1998). For example, suppressing the display of cued negative emotions (in a non-relationship context) has been linked to increased sympathetic system activation (Gross, 1998).

We conceptualize the potential moderators of the link between couple conflict and HPA-responsivity as either intra- and inter-personal. The intra-personal domain consists of individual traits and behavior problems that are either the consequence or cause of difficulties in emotional regulation. Emotional regulation here refers to a largely non-

volitional process that involves the modulation of emotional response to stimuli in the service of long-term goals. We hypothesized that individuals who demonstrate poor emotional regulation, and especially a tendency toward negative emotions, would show greater reactivity to adverse experiences such as couple conflicts.

We selected anxiety as an individual characteristic that embodies difficulties in emotional regulation corresponding to increased sensitivity and reactivity to perceived threat. Anxiety is associated with emotional regulation difficulties due to high levels of negative emotionality or deficits in inhibition (e.g., Barr, Kahn, & Schneider, 2008; Campbell-Sills, Barlow, Brown, & Hofmann, 2006; Nigg, 2006; Weems & Silverman, 2006). We hypothesized that anxiety would moderate physiological response to couple interaction. Thus, for high-anxious compared to lower-anxious individuals, greater negativity in couple interactions would lead to relatively greater increases in HPA reactivity (and thus cortisol) in response to couple conflict, which would persist for a relatively longer time.

A second potential moderator is stress within the inter-personal domain, here represented by chronic and unresolved couple conflict. The stressor in this study was a conflict episode in which couples attempted to resolve an outstanding conflict. We reasoned that chronic stress factors relating to the task at hand (rather than general relationship satisfaction) should be related to individuals' responses to a stressor. An individual who experiences frequent escalations of relationship conflict may be guarded about whether the apparent end of a bout of negativity with the partner is in fact just a brief pause before continuation of the argument. This vigilance Being guarded or vigilant in this way may delay recovery of cortisol to baseline. Thus, we hypothesized that a pattern of chronic, ineffective arguments in the relationship would moderate cortisol responses to couple interactions.

The Current Study

Our aim was to further understanding of the couple relationship during the transitional period of pregnancy through an investigation of cortisol response to couple interaction. We hypothesized that associations between the quality of couple interaction and HPA response would be conditioned by individual- and couple-level risks. Specifically, highly negative and low warmth interactions would be linked to relatively greater cortisol reactivity and less recovery at higher levels of risk. Moreover, we explored gender differences in these patterns.

There are two important reasons for studying these relations during pregnancy. First, insight into the relationship between couple interactions and HPA responsivity is important given that the mother and developing fetus are vulnerable to maternal stress. Expectant mother cortisol levels are associated with concurrent depression, anxiety, and sleep disturbance (Field, Hernandez-Reif, Diego, Schanberg, & Kuhn, 2006), as well as lower fetal growth, shorter gestation period, and lower birth weight (Field, Hernandez-Reif, Diego, Figueiredo et al., 2006). Second, an understanding of the links between prenatal conflict and stress may increase our awareness of the implications for individual and family well-being after birth (author citation removed). For instance, research has shown that prenatal couple relationship quality predicts interparental conflict and parenting quality after birth (Cox, Paley, Payne, & Burchinal, 1999).

In this study, several aspects of our analytic approach should enable more accurate research conclusions. First, a drawback to the use of couple conflict as a stressor is variability across couples in the degree of conflict. We handle this by incorporating process measures of the stressor, couple interaction, into the analyses. Second, we include measures of couple positivity and negativity as process measures. Some have argued that a focus on conflict in

the marital and couple relationship literature has to some extent neglected the important role played by affection in sustaining relationships. For example, affection may restrain reactivity to a partner's hostile outbursts, as well as facilitate more rapid recovery. Third, we examine separately the reactivity and recovery dimensions of the cortisol response to the interaction task. Finally, as described in more detail below, we pay careful attention to methodological issues: appropriate statistical models employed to deal with clustered data (i.e., the non-independence of men and women linked within couples), inclusion of theoretically and empirically significant control variables (e.g., time of day, number of weeks gestation for women), and measures based on different methods (i.e., self-report, observation) in the analyses. These features serve to improve the reliability of the findings.

Methods

Participants were heterosexual couples expecting their first child and participating in a randomized study testing a psychosocial prevention program for first-time parents (author citation removed). Only pretest data is included in the present study. Couples were primarily recruited from childbirth education programs at two hospitals located in small cities with nearby rural areas. Eligible couples were living together, both parents were over 18 years old and expecting their first child. The full study included 169 couples; however, we only attempted to collect cortisol from 138 for budgetary reasons. Of the 129 couples who agreed to provide these data, one couple's data was eliminated because both were ill at the time of sampling.

Participating couples resided in rural areas, towns, and small cities in central Pennsylvania. Eighty-two percent of couples were married (compared to the US average of 67% of new parents) and the majority of participants (91% of women and 90% of men) were Non-Hispanic White. The remaining participants were Non-Hispanic Black, Non-Hispanic Asian, Hispanic, or other races. Median annual family income was \$65,000.00 ($SD = \$34,372.79$), with a range of \$2,500.00 to \$162,500.00. Average educational attainment was 15.1 years for women ($SD = 1.8$) and 14.5 years for men ($SD = 2.2$); 14.4% of women and 29.3% of men did not complete any post-secondary school education. Mean ages were 28.3 ($SD = 4.9$) years for women and 29.8 ($SD = 5.6$) years for men.

Procedure—Data were collected during a home visit by a trained research assistant. Because of the typical declining diurnal pattern of cortisol production, we interviewed couples in the afternoon or evening: 83% of couples were interviewed after 2 pm, 73% after 4 pm. Women and men separately completed questionnaires regarding their relationship experiences, individual qualities and attitudes, and individual well-being. Additionally, interviewers collected two 12-minute videotaped interactions of each couple. Couples were first asked to talk about their day or about something that was on their mind not related to their relationship. Each partner took turns spending six minutes as the primary speaker and six minutes as the listener (male/female order was counterbalanced across couples). For the second task, couples were asked to talk about three problems in their relationship. The three problem areas for each couple were selected by the interviewer based on the highest rated items each partner had previously made concerning changes they would like in their partner. Topics included finances and spending, sharing household responsibilities, and communication patterns. This type of conflict discussion represents a mild stressor for most family members. Prior research has shown that some but not all family members' cortisol levels increase after a conflict discussion (Klimes-Dougan, Hastings, Granger, Usher, & Zahn-Waxler, 2001). Given our interest in individual differences, this type of stressor is appropriate.

Salivary Cortisol—During the course of the home interview, three salivary cortisol samples were obtained from participants. A baseline sample (t_0) was collected at the beginning of the home visit, after the interviewer explained the procedures and obtained consent. The participants completed some of the questionnaires while the interviewer spent about 10 minutes setting up the video equipment. The couple then engaged in the two 12-minute interactions. The 2nd sample (t_1 , reaction) was collected 15 minutes after the end of the second interaction, the conflict discussion. (The 2nd sample was collected on average about 50 minutes after the baseline sample.) Given the average of 20 minutes between stressor to peak cortisol level, we timed the 2nd sample in order to be about 20 minutes from the middle of the conflict discussion. Given our lack of knowledge concerning the peak conflict point in a 12-minute task, and the likely variability among couples, it seemed best to assume peak conflict towards the middle of that period. The 3rd sample (t_2 , recovery) was collected 20 minutes after the 2nd sample, by which time cortisol levels should have declined from the peak. Because cortisol levels are affected by recent meals, subjects were asked not to eat for one hour prior to the home visit; if the subject had report eating in that period, the cortisol-related tasks were conducted at the end of the home visit. Figure 1 provides a diagram of the home visit sequence and the corresponding average cortisol sampling time points.

After collection, saliva samples were kept on ice, frozen within 8 hours, and stored at -20 -degrees C until transported to Salimetrics laboratories (State College, PA). On the day of testing, samples were centrifuged at 3000 rpm for 15 minutes to remove mucins. Samples were assayed for salivary cortisol using an enzyme immunoassay US FDA (510k) cleared for use as an in vitro diagnostic measure of adrenal function. The test used 25 μ l of saliva, had a lower limit of sensitivity of .007 μ g/dL, range of sensitivity from .007 to 3.0 μ g/dL, and average intra-and inter-assay coefficients of variation of less than 5% and 10%. Cortisol units are expressed in micrograms per deciliter (μ g/dL).

Because of a moderate positive skew in the baseline sample as is typical of cortisol levels, log-transformed values of the first cortisol measure were used in the substantive analyses. However, measures of reactivity ($t_1 - t_0$) and recovery ($t_1 - t_2$) were computed from untransformed cortisol values, because the difference scores had approximately normal distributions. Larger reactivity values indicated an increase in cortisol level from t_0 to t_1 , and larger recovery values indicated a decrease in cortisol from t_1 to t_2 .

Couple Interaction—Undergraduate and graduate students were trained to rate videotaped interaction with a global rating system (5- and 7-point scales) adapted from previous work (Britner, Marvin, & Pianta, 2005; Margolin, Gordis, & Oliver, 2004; McHale, Kuersten-Hogan, & Lauretti, 2001; Schoppe-Sullivan, Mangelsdorf, Frosch, & McHale, 2004). Over 80% of dyadic interactions were double-coded, and percent close agreement (within one point) was 88% across all codes. *Positive* and *negative communication* scores for each partner consisted of average scores on multiple codes. These composites were based on exploratory factor analyses and confirmed with reliability coefficients (Cronbach's alpha of .80 and .85 for positivity and .83 and .87 for negativity, for women and men, respectively). Positive Communication consisted of six codes: Listening, Support, Problem Solving, Appreciation, Engagement, and Openness. Negative Communication included Demandingness, Hostility, and Contempt. Overall scores were averaged across parents. To reduce the influence of extreme cases, four negative communication values were truncated.

Intra-personal Risk—Anxiety was measured with the 20-item short form of the Taylor Manifest Anxiety Scale (MAS; Bendig, 1956; Taylor, 1953). Responses were dichotomous (e.g., "I am a high-strung person: Yes/No"). Reliability coefficients were .85 for women and .78 for men in this sample.

Interpersonal Risk—The Ineffective Arguing Inventory (Kurdek, 1994) assesses chronic couple conflict in which problems are not resolved and partners experience an ongoing sense of frustration. The scale employs eight items (e.g., “Our arguments are left hanging and unresolved), with a 5-point response scale (1= Strongly Disagree; 5 =Strongly Agree). Reliability coefficients were .89 for women and .87 for men.

Results

Descriptive statistics

The means (standard deviations) of the three cortisol assays (in ug/dl) for women were: $t_0 = .151 (.085)$, $t_1 = .127 (.072)$, $t_2 = .119 (.069)$; for men they were $t_0 = .088 (.058)$, $t_1 = .069 (.044)$, $t_2 = .060 (.036)$. Baseline cortisol was negatively associated with measurement time of day (women, $r = -.53$, $p < .001$; men, $r = -.60$, $p < .001$), in accordance with the normative diurnal decline of cortisol levels. Mean values for the three samples indicated that average cortisol level declined over the measurement period from t_0 to t_2 . Despite this overall trend, increased cortisol from t_0 to t_1 (defined by a change consisting of at least 10% from baseline and at least .02 ug/dl) was found in 14.9% of the women and 19.4% of the men. Given that the elevation in cortisol level we expected as a result of the couple discussion was countered by the diurnal pattern (see Discussion), from here on we refer to more or less reactivity/recovery as relative not absolute change in cortisol. Other studies have taken a similar approach to measuring individual differences in reactivity (e.g. Davies, Sturge-Apple, Cicchetti, & Cummings, 2008).

Baseline cortisol was found to be negatively correlated with reactivity (women, $r = -.60$, $p < .001$; men, $r = -.48$, $p < .001$) and had a moderate positive correlation with recovery (women: $r = .33$, $p < .001$; men: $r = .29$, $p = .001$). However, reactivity was not significantly correlated with recovery ($r = -.15$, and .08 for women and men, respectively). Baseline cortisol within couple were moderately associated ($r = .38$, $p < .01$), but within-couple associations were not significant for reactivity ($r = .14$, n.s.) or recovery ($r = -.15$, n.s.). Number of weeks gestation was positively associated ($r = .31$, $p < .001$) with women's baseline cortisol. Use of glucocorticoid medication (detected in our data for four men and five women) was not significantly associated with men's baseline cortisol.

Correlations for the two moderator variables within couple were under .40.

Analytic Strategy

Regression models were used to assess how the risk variables predict the cortisol outcomes. The models for reactivity had a multilevel structure, including a random intercept to accommodate variation in overall levels between couples. For models of cortisol recovery, we used regular regression models with standard errors adjusted for non-independence across couples (specifically, multilevel models could not provide proper estimates of random effects given lower between- couple variation on the recovery outcome (StataCorp, 2007)). We conducted separate analyses to examine how the observed couple communication style (positivity or negativity) and moderator (anxiety or ineffective arguing) jointly predicted cortisol levels. Thus, four models (for the two observed communication variables crossed with the two moderators) were executed for each of the reactivity and recovery dependent variables. For all models, we first examined the coefficients representing the main effects of both the observed communication variable and the moderator predicting reactivity or recovery. We then reexecuted each model with the addition of an interaction term between the communication variable and the moderator. This approach allowed us to examine how the two predictors (e.g., anxiety and degree of observed negative communication) may interact in their association with cortisol levels. We

assessed gender differences by including additional two- and three-way interaction terms (i.e., gender crossed with the couple communication variable, moderator variable, and the communication x moderator interaction term). Regression models included several control variables. Gender was represented by a dummy variable (0=male, 1=female). For reactivity models, we included the (log-transformed) baseline cortisol value as a control variable; for recovery models, we included both the baseline cortisol value and reactivity score as control variables. We also included two variables to control for measurement conditions: cortisol sample time of day and number of weeks gestation. Since the latter covariate might be relevant only for the prediction of cortisol among women, we included a gender x gestation interaction term as an additional control (removed if $p > .10$). Coefficients for control variables are not provided in tables, although results are described below where relevant (e.g., gender main effects).

Regression model results

We present results collectively from the eight analyses (involving separate sets of predictor variables) in order to highlight consistent findings across models. When gender interactions were found to be statistically significant, we re-ran the same models using a reversed gender dummy coding in order to examine the main effects for both men and women.

Gender Main effects—Gender differences were found in all eight regression models. For reactivity, gender differences were moderated by gestation: women had higher reactivity than men as the gestation period progressed (interaction term significant at least $p < .10$ across models). The same pattern was found in models examining baseline cortisol levels ($p < .01$). Results of models predicting cortisol recovery indicated that women had less average recovery than men, but without moderation by gestation period.

Main effects of couple communication style—Results indicated significant differences between women and men in the prediction of cortisol levels by the observed couple negative communication variable. Greater negative communication within couples was linked to higher reactivity ($b = .012$, $p < .05$), although a significant gender interaction ($b = -.017$, $p < .01$) indicated this was only the case for men. Likewise, greater negative communication was found to be linked with less cortisol recovery ($b = -.008$, $p < .01$), but again the gender interaction ($b = .013$, $p < .01$) indicated this finding was for men only.

We did not find positive communication to be predictive of reactivity. However, in our model for positive communication predicting recovery, a significant gender interaction ($b = .012$, $p < .05$) indicated differing associations among men and women: positive communication was linked to less recovery for women ($b = -.007$, $p < .05$, in a model where gender dummy was reversed) but not for men.

Main Effects of Anxiety and Ineffective Arguing—Our examination of the main effects of the moderators (before adding interaction terms) identified two significant findings. Anxiety was negatively associated with cortisol reactivity ($b = -.001$, $p < .05$). Anxiety also was associated with less recovery ($b = -.001$, $p < .01$) although for men only (gender interaction: $b = .002$, $p < .01$). Ineffective arguing was not found to be predictive of reactivity or recovery.

Moderation Analyses—We next examined whether the prediction of reactivity and recovery by observed couple communication quality was moderated by anxiety or ineffective arguing. In order to understand whether these 2-way interactions differed among men and women, we also included 3-way interactions that included the gender term. In cases where the gender x couple communication quality x moderator interaction was non-

significant, we then tested the 2-way moderation effect (communication quality x moderator) without the 3-way gender interaction term in the model (gender remained in the model as a control variable). In all cases, the 2-way moderation term was not significant when the 3-way term had not been significant. Results are presented in Tables 1 and 2. Because of a pattern of male/female differences in the findings for the couple communication quality x moderator term, the tables feature results from the models in which the gender (3-way) interactions are included.

For the four models predicting cortisol reactivity, we found a significant 3-way gender interaction only in the model for anxiety moderating positive communication (see Table 1). Specifically, among women with higher levels of anxiety, increased positive communication was associated with more cortisol reactivity. In contrast, for men with higher levels of anxiety, higher positive communication within the couple was associated with less reactivity.

In results for the models predicting cortisol recovery (Table 2), we found significant 3-way interaction terms in three of the four models. These results demonstrated gender differences in the interaction of negative communication style with each of the moderators, and in the model including the interaction of positive communication style with anxiety.

As noted above, men from couples with higher levels of negative communication demonstrated less cortisol recovery (not considering the joint impact of a moderator). Plots of the 3-way interaction terms indicated that this association between negative communication and cortisol recovery for men varied in a similar fashion across levels of both of the moderators. Figure 2 provides an example of the 3-way interaction, depicting the anxiety x negative communication interaction for men and women. The plot indicates that among those reporting higher levels of anxiety, greater couple negative communication was linked to less recovery for men, but more recovery for women. (The plot for ineffective arguing as the moderator, not shown, demonstrates the same pattern.) Post-hoc contrasts confirmed that the association between the level of negative communication and cortisol recovery (demonstrated in the plot) was significantly different between: (a) men and women who reported having higher levels of anxiety ($p < .01$); and (b) men and women who reported higher levels of ineffective arguing, although not at the conventional significance level ($p = .07$). For participants reporting lower levels of anxiety or ineffective arguing, we found no statistical difference in how negative communication predicted recovery between men and women, and no significant differences between men and women in how negative communication and anxiety (or ineffective arguing, in a separate model) interact to predict recovery.

Although not shown, the plot of the significant gender x positive communication x anxiety interaction result for recovery showed a similar pattern (but opposite in direction) to the corresponding interaction for reactivity (consistent with the gender differences demonstrated in Figure 2 for negative communication): positive communication was associated with more recovery for men who reported high levels of anxiety, but with less recovery for women who reported high levels of anxiety.

Discussion

The transition to parenthood for many couples is a period of great expectations coincident with increased stress and worry. This study aimed to help clarify the ways that couple interaction, in combination with existing individual and relationship difficulties, influences the psychobiology of stress for men and women during pregnancy. Of the two factors examined, anxiety demonstrated a significant main effect predicting less cortisol reactivity

and, for men, less recovery. It is possible that the other risk factors we measured are related to the *diurnal* pattern of adrenocortical activity, an important indicator of HPA functioning. However, we did not collect the data necessary to examine that issue. Instead, our main interest was in HPA responsivity to couple interaction.

Influences on adrenocortical reactivity

Negative communication during the couple interaction predicted increased cortisol reactivity for men, consistent with most prior research. In contrast, negative communication did not predict women's cortisol reactivity. However, women's levels of cortisol were already relatively high at baseline—which is normative for pregnancy (Mastorakos & Ilias, 2003). There may be a physiological ceiling effect in the sense that the typically mild stress of a couple conflict discussion was not powerful enough to further increase HPA axis activity above an already elevated level. Moreover, research indicates that HPA axis reactivity to stress is muted during pregnancy, an idea supported by several studies (e.g., Kammerer, Adams, von Castelberg, & Glover, 2002; de Weerth & Buitelaar, 2005; Sandman, Wadhwa, Chiciz-DeMet, Dunkel-Schetter, & Porto, 1997; Schulte, Weisner, & Allolio, 1990). Diminished reactivity in the context of already elevated levels of cortisol may represent a protective mechanism, as elevated cortisol has negative implications for the health of women and fetal development (Field, Diego, Hernandez-Reif, Gil, & Vera, 2005; Field, Hernandez-Reif, Diego, Figueiredo et al., 2006). This hypothesis does not imply that pregnant women are protected from social stress or do not experience it, but only that the functioning of pregnant women's HPA axis is altered such that transient social stress is not reflected in elevated levels of cortisol.

We also examined whether individual or couple risk factors modulated the association between couple interaction quality and cortisol reactivity. The two risk factors (anxiety and ineffective arguing) did not appear to condition the way the HPA system responded to negative couple interaction. This finding does not support our hypothesis that ongoing risk factors would account for individual differences in reactivity to couple conflict.

However, we did find that anxiety moderated the association between positivity and cortisol reactivity, and did so in a different manner for women and men. Higher levels of warmth during the couple discussion were associated with less reactivity for highly anxious men. This finding is consistent with our understanding of anxiety as associated with vigilance, sensitivity, and heightened reactivity to one's surroundings, and of warmth as calming. For anxious men, warmth in an interaction may be experienced as reassuring or soothing, leading to diminished HPA axis reactivity. The finding for anxious women was in the opposite direction: more warmth was associated with more cortisol reactivity. This is not the first study to find positive interaction related to greater cortisol response (Fehm-Wolfsdorf et al., 1999). We return to this finding below.

Influences on adrenocortical recovery

The link between negative couple interaction and cortisol recovery was conditioned by the combination of gender and both individual psychological and chronic couple difficulties. The results were consistent across both models for negativity. Figure 2 presents the plot of the gender x anxiety x negative communication interaction as an example. There is little relation between negative communication and cortisol recovery for men and women with low anxiety (or chronic arguing). The figure shows that greater negative communication leads to slightly less recovery for both low anxiety men and women. However, among individuals with higher levels of anxiety (or ineffective arguing, based on a separate model), the link between negative communication and recovery differs for men and women. For anxious men, the association is in the same direction as for men with low anxiety (i.e.,

greater negativity in the couple discussion is associated with less cortisol recovery), although the association is much stronger. (These results for negativity are mirrored by the results for warmth in couple interaction: anxious men show a steeper positive relation between positive communication and recovery than do less anxious men.) Thus, as we hypothesized, it appears that anxiety and a history of ineffective arguing reduce men's HPA-axis recovery following a social stressor.

This finding is important in at least two ways. First, by disrupting HPA axis recovery from stress, individual psychological difficulties or external stressors may contribute to poor health via higher levels of cortisol. Second, diminished cortisol recovery after a couple conflict discussion has been linked to men's psychological aggression and perpetration of injury toward partners over the previous year (author citation removed). Men who have difficulty with physiological recovery may remain in a state primed to react angrily to repeated conflict bursts, or to misconstrue ambiguous social signals.

For women with elevated scores on either moderator, the direction of the association was contrary to expectations: greater negative communication was associated with greater recovery. These findings are consistent with the findings for positivity and both reactivity and recovery for anxious women. Across all of these results, low positivity/high negativity is linked with less cortisol reactivity or greater recovery. This counter-intuitive finding is consistent with a prior study of dating couples: women with an avoidant attachment pattern experienced greater cortisol recovery after a conflict discussion than did non-avoidant women, and there was no difference between avoidant and non-avoidant men (Powers et al., 2006).

One explanation for these unexpected findings relates to the primacy of relational engagement for women. This account recognizes that low negativity or high positivity is maintained during a conflict discussion with some degree of effortful inhibition (Pennebaker & Chew, 1985)—which appears to draw on a limited capacity pool that can become temporarily depleted (Muraven & Baumeister, 2000). Inhibition of negative emotions and expression of dissonant emotions depletes self-control resources and increases sympathetic arousal (Robinson & Demaree, 2009; Schmeichel, Demaree, Robinson, & Pu, 2006). Given the greater salience of emotional dimensions of relationships to women, it may not be surprising that women who suppress negative behavior with a partner experience greater negative affect and emotional arousal than their male counterparts (Verhofstadt, Buysse, De Clercq, & Goodwin, 2005).

As hypothesized in the introduction, high levels of anxiety or chronic stress may weaken resources needed to regulate or inhibit negative emotions (e.g., Qina, Hermansa, Marlea, Luoc, & Fernández, 2009). Although warmth or low negativity in an interaction may generally be associated with a shorter period of stress, for women with anxiety or chronic stressors the effort required to inhibit a tendency towards negativity may be experienced as particularly stressful.

Limitations and Conclusion

There are several limitations in this study. First, as our intention was to examine relationships and cortisol among couples during pregnancy, the results may not generalize to all couples. Moreover, the differences we found between the patterns of moderation of cortisol reactivity/recovery for men and women could be linked to women's pregnancy status. Although the investigation of pregnant women's cortisol fluctuation is important in and of itself, further study is needed to assess whether the results are consistent for women who are not pregnant.

Second, the conflict discussion was intended to be a mild stressor increasing cortisol levels in some but not all participants. Moreover, factors that countered an increase in cortisol were several: the overall decline in cortisol over time, potential initial reactivity to the beginning of the procedure (i.e., the research assistant entering the home), the naturalistic setting (couples' own homes), and each couple's ability to jointly determine the intensity of the conflict stressor through their engagement in conflict. These factors cannot be completely disentangled in the framework of this study. Third, our underlying hypothesis concerns emotional regulation; yet because a measure of this construct was not available in the study, we utilized available variables as moderators that implicated emotion regulation. Further research on moderators of HPA responsivity to couple conflict should examine a range of other individual and external factors. For example, it would be important to examine whether a history of negative life events, coping style, or depression account for individual differences in stress responsivity. Fourth, our measure of couple communication style is based on an observational rating. Researchers frequently have found that observational and self-report measures are not highly correlated, although each is associated with important outcomes and thus appear valid. It is possible we would find different results if this construct were based on a self-report measure alone or a composite of self-report and observer scores. Finally, future research should examine the degree to which other individual characteristics (e.g., history of negative life events, coping style, depression) and external difficulties (e.g., financial stress) act in a similar manner as anxiety and ineffective arguing.

This study contributes to the growing understanding of how social interaction is related to HPA functioning and health. Kiecolt-Glaser and Newton's review highlighted gender differences in the implications of relationship conflict for health (Kiecolt-Glaser & Newton, 2001). Our results suggest that men and women—or at least expectant fathers and mothers—respond differently to couple interaction on a physiological level in the presence of ongoing individual and relationship difficulties such as anxiety or chronic relationship conflict.

The differences found for men and women in this study are provocative. The efficacy of interventions targeting enhanced couple functioning may be enhanced by incorporating the implications of these findings. For example, for optimal relationship functioning, partners may need to learn to carefully calibrate the level of couple discussion of conflictual issues. Such calibration may need to balance the apparently beneficial effect of conflict discussion for women experiencing individual or couple difficulties with the apparently negative effect for men experiencing such difficulties.

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Figure 1.
Home visit procedure and average timing for the three cortisol samples (T_0 , T_1 , T_2)

Figure 2.
Interaction of Anxiety and Couple Negative Communication Predicting Cortisol Recovery

Table 1

Results of multilevel regression models predicting Cortisol Reactivity

Observed Communication:	Cortisol Reactivity			
	Negative Communication		Positive Communication	
	Beta	z	Beta	z
Moderator: Anxiety				
Observed Couple Communication	0.013 *	2.47	-0.004	-0.79
Anxiety	-0.001	-1.43	-0.001	-1.28
Gender X Observed Communication	-0.017 *	-2.28	0.006	0.84
Observed Communication X Anxiety	0.001	0.81	-0.001	-0.88
Gender X Anxiety	0.000	-0.27	0.000	0.22
Gender X Obs. Comm. X Anxiety	-0.002	-1.10	0.005 *	2.44
Moderator: Ineffective Arguing				
Observed Couple Communication	0.011 *	2.05	-0.002	-0.42
Ineffective Arguing	0.000	-0.30	0.000	0.17
Gender X Observed Communication	-0.016 *	-2.00	0.009	1.14
Obs. Comm. X Ineffective Arguing	0.000	0.48	0.000	-0.09
Gender X Ineffective Arguing	0.000	-0.16	0.000	-0.16
Gender X Obs. Comm. X Ineffect. Arguing	0.000	-0.22	0.001	0.84

Notes.**
p < .01;*
p < .05. Not tabled are model intercepts and control variables: baseline cortisol level, sampling time-of-day, gender, number weeks gestation, and gender x number weeks gestation interaction.

Table 2

Results of regression models predicting Cortisol Recovery

Observed Communication:	Cortisol Recovery			
	Negative Communication	Positive Communication		
	Beta	t	Beta	t
Moderator: Anxiety				
Observed Couple Communication	-0.008 **	-2.93	0.005 *	2.25
Anxiety	-0.001 **	-3.06	-0.001 **	-3.10
Gender X Observed Communication	0.011 *	2.58	-0.011 *	-2.37
Observed Communication X Anxiety	-0.001 *	-1.58	0.002 *	2.52
Gender X Anxiety	0.002 **	2.85	0.002 **	2.66
Gender X Obs. Comm. X Anxiety	0.003 **	2.79	-0.002 *	-2.21
Moderator: Ineffective Arguing				
Observed Couple Communication	-0.006 **	-2.84	0.003	1.14
Ineffective Arguing	0.000	0.31	0.000	-0.18
Gender X Observed Communication	0.010 *	2.37	-0.009 *	-2.17
Obs. Comm. X Ineffective Arguing	-0.001 **	-2.66	0.001 *	2.21
Gender X Ineffective Arguing	0.000	0.38	0.000	0.48
Gender X Obs. Com. X Ineffect. Arguing	0.002 *	2.52	-0.001	-0.94

Notes.**
p < .01;*
p < .05. Not tabled are model intercepts and control variables: baseline cortisol level, sampling time-of-day, gender and number weeks gestation. Regression model standard errors adjusted for within-couple clustering.