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Mindful Parenting Predicts Mothers' and Infants' Hypothalamic-Pituitary-Adrenal Activity During a Dyadic Stressor

Heidemarie K. Laurent
University of Oregon and University of Illinois Urbana-Champaign

Larissa G. Duncan
University of Wisconsin-Madison

April Lightcap
University of Oregon

Faaiza Khan
University of Illinois Urbana-Champaign

Mindfulness in the parenting relationship has been proposed to help both parents and children better regulate stress, though this has not yet been shown at the physiological level. In this study, we tested relations between maternal mindfulness in parenting and both mothers' and their infants' hypothalamic-pituitary-adrenal (HPA) axis activity during a dyadic stressor 3 months later. Participants were 73 mother–infant dyads from a larger longitudinal study. At 3 months postpartum, mothers completed self-report measures of general dispositional mindfulness and parenting-specific mindfulness, as well as stressful life events. At 6 months postpartum, mother–infant dyads completed the Still Face task. Four saliva samples were collected from each dyad member for cortisol assay to index the HPA axis response. Hierarchical linear modeling of cortisol trajectories revealed a main effect of maternal parenting-specific mindfulness (mindful parenting), but not general dispositional mindfulness, on mothers' cortisol; mothers with higher mindful parenting showed steeper cortisol recovery slopes. In addition, maternal mindful parenting moderated the effect of life stress on later mother and infant cortisol. In the context of high life stress, maternal mindful parenting predicted lower infant cortisol levels, but more extended maternal cortisol elevations. Implications for a biobehavioral model of mindful parenting are discussed.

Keywords: mindfulness, mother, infant, cortisol, stress

Mindfulness in the parenting relationship has been proposed to promote both parent and child well-being, in part through the parent's ability to cope more effectively with stress that arises (Duncan, Coatsworth, & Greenberg, 2009). Such parental mindfulness may both support healthy responding to acute parenting stressors and alter the impact of background life stressors on coping within the parent–child relationship. However, little is known about whether parenting-specific mindfulness (mindful parenting) exerts unique effects over and above more general dispositional mindfulness, and how it may relate to physiological (as opposed to subjective) stress outcomes. The current study was designed to test associations between maternal mindful parenting and both mothers' and their infants' hypothalamic-pituitary-adrenal (HPA) axis activity during a dyadic stressor, as well as the potential moderating role of maternal mindfulness in effects of life stress on mother and infant HPA axis activity.

Although mindfulness—defined as a present-centered, nonjudgmental awareness of unfolding experience (Kabat-Zinn, 2003)—has typically been studied as an intrapersonal phenomenon, there is growing interest in the ways mindful qualities may influence interpersonal functioning. As proposed by Duncan and colleagues (2009), mindful parenting involves (a) listening with full attention, (b) nonjudgmental acceptance of self and child, (c) emotional awareness of self and child, (d) self-regulation in the parenting relationship, and (e) compassion for self and child. Although each of these dimensions is thought to operate across the age spectrum, their meaning is likely to depend on the child's developmental stage. In particular, mindful parenting with an infant requires careful attention to nonverbal communication and an ability to regulate one's responses to raw expressions of negative emotion (i.e., crying). The emotions to interpret may be less nuanced than in older children, but also harder to contain without the aid of verbal mediation.

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Heidemarie K. Laurent, Department of Psychology, University of Oregon, and Department of Psychology, University of Illinois Urbana-Champaign; Larissa G. Duncan, Human Development and Family Studies, University of Wisconsin-Madison; April Lightcap, Department of Psychology, University of Oregon; Faaiza Khan, Department of Psychology, University of Illinois Urbana-Champaign.

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Correspondence concerning this article should be addressed to Heidemarie K. Laurent, Department of Psychology, University of Illinois Urbana-Champaign, 603 East Daniel Street, Champaign, IL 61820. E-mail: hlaurent@illinois.edu

These characteristics of mindful parenting are, in turn, thought to contribute to superior parent and child outcomes via enhanced parental well-being (including reduced distress and increased efficacy in the parenting relationship) and higher quality parent–child interactions. Indeed, participation in a mindful parenting intervention has been shown to reduce maternal stress, distress, and anxiety (Perez-Blasco, Viguer, & Rodrigo, 2013), and to improve the affective quality of parent–child interaction (Coatsworth, Duncan, Greenberg, & Nix, 2010). Individual differences in mindful parenting have similarly been associated with lower parent distress and more positive parent–child relationships, as measured by both self-report and observational measures (Beer, Ward, & Moar, 2013; Duncan, Coatsworth, Gayles, Geier, & Greenberg, 2015; Lippold, Duncan, Coatsworth, Nix, & Greenberg, 2015).

There is also research linking parental mindfulness to fewer child behavior problems, though the specificity of effects to mindfulness in the parenting relationship and the mechanisms for such effects require further study (Parent et al., 2010). In particular, although several studies have linked more general measures of mindfulness to parenting behaviors and/or child outcomes (Parent et al., 2010; Williams & Wahler, 2010), family researchers propose that measuring mindfulness specifically within the parenting relationship will yield greater insight into parent–child processes (Duncan et al., 2009). Recent research has shown that mindful parenting mediates links between general dispositional mindfulness and parenting stress, as well as other parenting behaviors (Gouveia, Carona, Canavarro, & Moreira, 2016). Clinical intervention research focused on mindful parenting has shown general dispositional mindfulness improvements to be linked with less parent psychopathology, whereas reductions in child psychopathology were predicated by improvements in mindful parenting (Meppelink, de Bruin, Wanders-Mulder, Vennik, & Bögels, 2016). Thus, we would expect outcomes related to parent–child interaction and/or child adjustment to be more closely related to mindful parenting, whereas general dispositional mindfulness would be more distally related to such outcomes. One promising but still unexplored route by which mindfulness in parenting may impact both parent and child outcomes is via physiological stress regulation during challenging parent–child interactions.

The HPA axis is an important target for understanding ways in which a parent's orientation to stress may contribute to their own and their children's well-being. This neuroendocrine system responds to physical or psychological stress by releasing cortisol from the adrenal gland, which, in turn, prepares the organism to deal with threat. Whereas moderate, time-limited cortisol elevations are thought to be adaptive, more extreme and/or protracted elevations have been associated with internalizing difficulties in both children and adults (e.g., Guerry & Hastings, 2011; Tafet & Nemeroff, 2016). Research on cortisol in situations of acute stress has yielded inconsistent conclusions about how HPA axis *activation*—indexed by cortisol levels—relates to adjustment, with some studies relating higher cortisol and others lower cortisol to psychopathology (e.g., Fairchild et al., 2008; Hankin, Badanes, Abela, & Watamura, 2010; Laurent, Gilliam, Wright, & Fisher, 2015; Powers, Laurent, Gunlicks-Stoessel, Balaban, & Bent, 2016). One way of reconciling these findings is to take into account the risk context in which a person is embedded; according to the biological sensitivity to context theory (Boyce & Ellis, 2005), greater HPA activation during acute stress may be advantageous for children growing up in a protected environment (making them more sensitive to subtle environmental cues), yet this profile would be a liability for those growing up in a threatening environment that chronically activates the system. More consistently, research has suggested that timely HPA axis *recovery*—indexed by the degree to which cortisol declines promptly following stress—is important for mental health (see Burke, Davis, Otte, & Mohr, 2005; Dienes, Hazel, & Hammen, 2013).

Several studies have demonstrated relations between general dispositional mindfulness and HPA activation during, and/or recovery following, psychosocial stress. One study involving a standard performance task revealed elevated responses—both higher cortisol levels during stress and incomplete recovery—among those with lower mindfulness scores (Brown, Weinstein, & Creswell, 2012). Another study revealed both positive and negative associations with romantic partners' cortisol in response to an interpersonal stress task (Laurent, Laurent, Hertz, Egan-Wright, & Granger, 2013); whereas women's mindfulness predicted higher cortisol levels, men's mindfulness predicted less pronounced task-related reactivity and recovery curves. The divergent mindfulness-related cortisol profiles in the latter study—each of which related to markers of mental health—are consistent with the idea that mindfulness does not always reduce the stress response, but rather buffers *or* sensitizes the HPA axis to best meet the demands of a particular person in a particular situation. This idea has yet to be investigated in the context of the parent–child relationship.

During the first year postpartum, mothers' experiences of stress and impacts on infant stress regulation may be particularly important (e.g., Dawson, Hessl, & Frey, 1994; Essex, Klein, Cho, & Kalin, 2002). Mothers who are unable to respond sensitively to their infant's emotional bids and/or to engage positively with their infant tend to promote HPA hyperactivation, which, in turn, is associated with behavioral and emotional difficulties (e.g., Bosquet Enlow et al., 2014; Hostinar, Sullivan, & Gunnar, 2014). Thus, mindfulness in the parenting relationship may help to regulate not only the mother's stress responding but also—via effects on parenting behavior—that of her infant. For example, when faced with infant distress, the mother's accurate awareness of her infant's emotional needs (separate from her own) and ability to regulate her own responses should allow her to engage positively and soothe the infant in a way that lowers the infant's cortisol. For the mother herself, such emotional awareness paired with full attention to what is actually occurring—as opposed to fears about what is coming or regrets about what has happened—may allow her to recover (i.e., lower her own cortisol levels) more quickly.

At the same time, the optimal response may not always involve lower cortisol; there is evidence that lower maternal cortisol during the Still Face (SF) task, a standard mother–infant stress task, relates to disrupted mother–infant communication in a high-risk sample (Crockett, Holmes, Granger, & Lyons-Ruth, 2013). As proposed by Crockett et al. (2013), low maternal HPA axis activation during such an interaction may reflect limited access to both the mother's own and her infant's emotional experience, impairing her ability to attune to and respond sensitively to her infant. It is thus possible that mindful parenting, by enabling open awareness of one's own and infant distress, could actually promote more pronounced/extended cortisol elevations in contexts in which such elevations are warranted or beneficial.

Beyond main effects on acute stress responses, mindful parenting may influence parent/child functioning by moderating the impact of more chronic life stress on in-the-moment coping. Stressful life circumstances—that is, low income, minority status, and/or low social support—have been associated with higher cortisol output in both mothers and their infants (Jewell, Luecken, Gress-Smith, Crnic, & Gonzales, 2015; Palmer et al., 2013), with less positive and more negative parenting behaviors identified as a mechanism by which infants' cortisol is affected (Martinez-Torteya et al., 2014; Taylor et al., 2013). There is some evidence that general dispositional mindfulness can buffer the HPA axis from certain types of stress experiences (Daubenmier, Hayden, Chang, & Epel, 2014; Laurent, Hertz, Nelson, & Laurent, 2016). Applied to parenting, maternal mindfulness could modify the influence of stressful life events in different ways. On the one hand, the decentering from troubling thoughts and emotions facilitated by mindfulness may buffer the mother from the influence of background stressors; on the other hand, a backdrop of objectively challenging or threatening circumstances may heighten mindfulness-mediated awareness of, and sensitivity to, negative emotions. This idea is consistent with neuroimaging findings demonstrating mindfulness-related structural and functional enhancement of brain areas involved in both the felt experience and metacognitive awareness of emotions (e.g., Hölzel et al., 2011; Kong, Wang, Song, & Liu, 2016; Smoski et al., 2015).

In the current study, we aimed to test predictions about stress regulation based on mindful parenting theory (Duncan et al., 2009) at the physiological level. In particular, we examined the effects of maternal mindfulness in parenting at 3 months postnatal on mothers' and their infants' cortisol during a laboratory session involving the SF at 6 months postnatal. Both main effects of maternal parenting-specific and general dispositional mindfulness and interaction effects with mother-reported life events were tested. Based on the tenets of mindful parenting theory and the relevant empirical research reviewed above, we hypothesized that parenting-specific mindfulness, but not more general dispositional mindfulness, would relate to lower mother and infant cortisol levels and/or a steeper recovery slope during the SF session. We further expected that mindful parenting would modify the impact of life events, which could result in buffering (i.e., lower cortisol levels and quicker recovery, especially for infants) and/or sensitization (i.e., heightened cortisol levels and delayed recovery, especially for mothers) as outlined above.

Method

Participants

Participating mothers and their infants were part of a longitudinal study of stress regulation, which included 91 dyads at the first assessment. Mothers of infants less than 12 weeks old were recruited from the Women, Infants, and Children (WIC) program and from other community agencies serving low-income mothers. Reflective of the community from which they were drawn, the majority of mothers (77%) were White. Maternal ages ranged from 18 to 44 years ($M = 27.0$, $SD = 5.4$). Approximately half (51%) were either married or in a legal domestic partnership at the time of recruitment, and for 48% of women, this was their first child (33% second child, 19% third or later). A minority (19%) of mothers were college graduates, and median reported household income was in the $10,000 to $19,999 range. A substantial proportion (54%) reported having engaged in some type of contemplative practice, including yoga ($n = 32$), martial arts ($n = 6$), self-reflection or prayer ($n = 5$), and meditation ($n = 9$). We found no differences between those who did and did not report a contemplative practice on any demographic or study variables, including mindfulness. The current analyses are based on the 73 mother–infant dyads (63% with female infants) who completed all study measures at both 3-month and 6-month sessions (see below for more information on assessment times). A comparison of those included versus excluded revealed no significant differences in study variables, though the former group did report higher educational attainment (21% vs. 7% college graduates) and household income (median $20,000 to $29,999 vs. <$5,000 range), $t(89) = 2.14–2.71$, $p < .05$.

Procedures

The data for this study are drawn from the first two assessments in a larger study of infant stress system development across the first year and a half of life. When their infant was approximately 3 months old, mothers completed a set of online questionnaires that included the self-report measures listed below. At approximately 6 months postnatal, mothers and their infants took part in a laboratory session involving the SF task and saliva sampling for cortisol.

Both the mother and the infant gave four saliva samples over the course of the session: the first sample (start time range 11:52 a.m. to 4:33 p.m.) was collected soon after arrival at the lab, following a set of questions about factors that could affect salivary hormone measures; the second was collected directly after the SF task ended; the third was collected 15 min later (20 min after peak stress of the SF; see below); and the fourth was collected 30 min after the preceding sample. Mothers were instructed to deposit saliva via passive drool into a collection container, and infants' saliva was collected via infant swab by a research assistant with the mother's help.

The SF task is a standardized procedure to observe interaction between a parent and his or her 2- to 9-month-old infant during a somewhat stressful situation (see Toda & Fogel, 1993). The task comprised three episodes: 2 min of playful interaction between the mother and her infant, 2 min during which the mother was asked to "show an expressionless or blank face to your baby, and try not to touch or talk to your baby" (still face, or peak stress), and a final 2 min during which the mother was allowed to freely re-engage with her infant. Throughout the procedure, the infant (in an infant seat) faced the seated mother.

Measures

Interpersonal Mindfulness in Parenting—Infant Version (IMP-I). This measure represents an adaptation of the Interpersonal Mindfulness in Parenting measure (Duncan, 2007; Duncan et al., 2009) for the infant stage of development and comprises 27 items rated on a 5-point scale from *never true* to *always true*. Representative items include "I pay close attention to my baby when we are spending time together," "I notice how changes in my baby's mood affect my mood," "When things I try to do as a parent do not work out, I can accept them and move on," and "I often react negatively when my baby fusses or cries" (reverse scored). Internal consistency for the

scale was good (Cronbach's alpha = .81). Total IMP-I scores ranged from 3.17 to 4.77 (M = 4.16, SD = .36).

Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). The FFMQ measures general dispositional mindfulness with 39 items rated on a 5-point scale from *never or very rarely true to very often or always true*. Example items include "I find it difficult to stay focused on what's happening in the present" (reverse-scored) and "When I have distressing thoughts or images, I just notice them and let them go." Cronbach's alpha for the total scale was .89. Total FFMQ scores ranged from 2.70 to 4.69 (M = 3.63, SD = .52).

Life Events (LE) Scale (Dohrenwend, Askenasy, Krasnoff, & Dohrenwend, 1978). Mothers indicated which stressors they had experienced since the birth of their infant (past 3 months) using the Psychiatric Epidemiology Research Interview Life Events Scale. This scale includes 102 possible events from 11 life domains: school, work, love and marriage, having children, family, residence, crime and legal matters, finances, social activities, health, and miscellaneous. A summed score representing the total of all types of life events experienced since the infant's birth was used in analyses. Total scores ranged from zero to 28 events (M = 4.41, SD = 4.16; 12.4% reported zero events, 24.8% reported one to two events, 21.6% reported three to four events, 21.6% reported five to six events, and 19.6% reported seven or more events).

Cortisol. Mothers' and infants' saliva samples were assayed in duplicate with the commercially available Salivary Cortisol Enzyme Immunoassay (Salimetrics, Carlsbad, CA) without modification to the manufacturer's recommended protocol. The test uses 25 μl saliva, has a lower limit of sensitivity of .007 μg/dl, and a standard curve range from .012 μg/dl to 3.0 μg/dl. The intra-assay coefficient of variation was, on average, less than 10%, and the inter-assay coefficient of variation was, on average, less than 15%. Cortisol scores were natural log-transformed prior to analysis to correct positive skew.

Analytic Strategy

Hierarchical linear modeling using the HLM 6.08 program was selected to analyze effects of maternal mindfulness on mothers' and infants' cortisol trajectories (Raudenbush & Bryk, 2002). This approach divides variability in the outcome—in this case, cortisol—into within-person and between-person components to obtain more accurate standard errors for testing regression coefficients. At Level 1, mother or infant cortisol was modeled with an intercept (β_0, representing cortisol level) and, if found to improve model fit, one or more temporal components (i.e., linear term β_1, representing the rate of cortisol recovery; quadratic term β_2, representing the overall steepness of the response curve). At Level 2, between-person differences in these trajectory components could be explained by adding hypothesized predictors. For illustration, the two-level equations testing (a) main effects of general dispositional mindfulness and parenting-specific mindfulness, and (b) Parenting-Specific Mindfulness × Life Events interaction effects on mothers' cortisol are shown:

Level 1

$$\text{Mother Cortisol} = \beta_0 + \beta_1(\text{time}) + \text{error}$$

Level 2

(a) $\beta_0 = \gamma_{00} + \gamma_{01}(\text{FFMQ total}) + \gamma_{02}(\text{IMP-I total}) + \text{error}$

$\beta_1 = \gamma_{10} + \gamma_{11}(\text{FFMQ total}) + \gamma_{12}(\text{IMP-I total}) + \text{error}$

(*b*) $\beta_0 = \gamma_{00} + \gamma_{01}(\text{IMP-I total}) + \gamma_{02}(\text{Life Events total}) + \gamma_{03}(\text{IMP-I} \times \text{Life Events}) + \text{error}$

$\beta_1 = \gamma_{10} + \gamma_{11}(\text{IMP-I total}) + \gamma_{12}(\text{Life Events total}) + \gamma_{03}(\text{IMP-I} \times \text{Life Events}) + \text{error}$

Results

Control Variables

Prior to model testing, a number of variables that could impact salivary cortisol were examined for influence. These included the infant's sex, saliva sampling start time, recent intake of food, tooth brushing, dental work, illness, use of prescription and nonprescription drugs and alcohol in the past 24 hr, wake time, hours of sleep, exercise, and body mass index. Of these, mothers' use of pain medications, caffeine intake that day, and exercise that day were found to relate to cortisol trajectories; however, their inclusion failed to alter model results (all coefficients within 98% confidence interval of the original), so the more parsimonious models containing only hypothesized predictors are reported.

Baseline Models of Mother and Infant Cortisol

First, baseline HLM models containing no explanatory predictors were fit to describe sample-wide mother and infant cortisol trajectories during the SF session. For mothers, a linear model including an intercept (representing cortisol level at the third, or peak stress, saliva sample) and slope (representing rate of cortisol decline across samples, or recovery) provided the best fit to the data according to change in the deviance statistic: significant improvement from intercept-only to linear model, $\chi^2(3) = 130.91$, $p < .001$; nonsignificant improvement from linear to quadratic model, $\chi^2(4) = 7.56$, $p = .11$. For infants, on the other hand, adding a linear term resulted in a nonsignificant fit improvement, $\chi^2(3) = 4.79$, $p = .19$, so an intercept-only model (representing mean cortisol level across samples) was selected.

HLM tau statistics, which represent the variance and covariance of terms allowed to vary as random effects at Level 2, were examined to determine whether there was meaningful variability in mother/infant cortisol terms to be explained. These demonstrated significant between-person variability in all model terms, $\chi^2(72) = 214.44–1119.80$, ps $< .001$, indicating that mothers and infants showed varying degrees of HPA activation during and (for mothers) recovery following the task. Thus, predictor variables were added at Level 2 to explain this response variability. First, we tested main effects models with maternal mindfulness predicting mother and infant cortisol; in a second step, we tested moderation models with maternal Mindfulness × Life Events effects.

Explanatory Models: Main Effects of General Dispositional Mindfulness and Parenting-Specific Mindfulness on Mother and Infant Cortisol

Total scores for both maternal general dispositional mindfulness (FFMQ) and parenting-specific mindfulness (IMP-I) at 3 months postnatal were entered as predictors of mother and infant cortisol at 6 months. For mothers, parenting-specific (but not general) mindfulness predicted a more negative linear term, indicating

faster stress recovery (see Table 1, Part A). This model explained 14% of the variance in mothers' linear terms. No main effects of either maternal general or parenting-specific mindfulness on infants' cortisol were found.

Explanatory Models: Mindfulness × Life Stress Effects on Mother and Infant Cortisol

To assess possible stress-moderating effects of mindfulness, interactions between total maternal mindfulness scores and stressful life events at 3 months were tested as predictors of mother and infant cortisol trajectories at 6 months. Mindful parenting was found to significantly moderate the effect of life events on both mothers' and their infants' cortisol (see Table 1, Part B1). These models explained 24% of the variance in mothers' linear terms and 10% of the variance in infants' intercept terms. No general Dispositional Mindfulness × Life Events effects reached significance (Table 1, Part B2), so these models are not discussed further.

Region of significance calculations were used to decompose these interaction effects. For mothers with low IMP-I scores (42nd percentile and lower), life events predicted faster stress recovery; for mothers with high IMP-I scores (71st percentile and above), life events predicted the opposite, a more extended cortisol response. For the infants of mothers with high IMP-I scores (68th percentile and above), life events predicted lower cortisol levels (nonsignificant effects at lower IMP-I values, though the effect at the lowest observed value was marginal, slope = .92, standard error = .48, $p = .057$). Figure 1 and Figure 2 show predicted effects of life events on mothers' cortisol linear terms and infants' cortisol intercepts at the boundaries of the region of significance.

Summary

The above model results suggest that mindful parenting during the early postnatal period can aid in maternal physiological stress recovery during interactions with her infant. At the same time, parenting-specific mindfulness appears to moderate the impact of early postnatal life stress on later mother and infant physiological stress in different ways. In the context of high life stress, mothers high in mindful parenting showed extended HPA axis engagement, or delayed recovery (sensitization), whereas the infants of these mothers showed lower HPA axis activation (buffering).

Discussion

In this study, we tested the proposal that mindful parenting would help to explain the way mothers and their infants respond to stress at the physiological level. As predicted, parenting-specific mindfulness, but not general dispositional mindfulness, during the early postpartum period predicted steeper maternal HPA axis recovery slopes during an infant-related stressor. This suggests that more attention should be paid to mindfulness not as a set of decontextualized qualities, but rather as skills exercised in a particular life context. It may be especially important to study how mindfulness shapes functioning within interpersonal relationships, a context where these qualities can be both difficult to embody and critical for well-being. Research involving different types of interpersonal and noninterpersonal stressors should be used to further investigate the specificity of mindfulness effects to stressor domains.

In contrast to the effect for mothers, we found no main effects of maternal parenting-specific mindfulness on infant cortisol. As suggested by previous researchers, mindful parenting effects on child outcomes may be indirect, operating via parenting practices (e.g., Parent et al., 2016). It may also be important to examine infants' HPA functioning at different ages and/or in response to different stressors to observe an impact. Finally, it is possible that effects of maternal mindful parenting on children's cortisol only emerge within a particular life context.

In line with predictions that mindful parenting would modify the impacts of life stress, we found that parenting-specific mindfulness moderated the effect of early postpartum life events on mother/infant cortisol. For infants, we found the expected buffering effect; when the mother was high in mindful parenting, life events related to lower infant cortisol levels. At the lowest levels of mindful parenting, there was a trend for the opposite effect—that is, life events relating to higher infant cortisol. Mothers who are more mindful during parenting interactions may be better able to decenter from other stressors, maintaining or even increasing sensitivity to their infant's moment-to-moment needs in difficult times. On the other side, mothers with low levels of mindful parenting may allow life stress to spill over into

Table 1
Associations Between Maternal Mindfulness and Mothers' and Infants' Cortisol

Predictor	Mothers		Infants
	Intercept β, *SE*	Linear β, *SE*	Intercept β, *SE*
A. Main effects			
FFMQ total	−.020, .10	.034, .036	.003, .09
IMP-I total	−.010, .11	−.095*, .037	.12, .10
B. Interaction effects			
1. IMP-I total	−.030, .10	−.083*, .035	.13, .096
Life events	.071, .10	−.038, .033	.026, .092
IMP-I × Life Events	.17, .15	.14*, .051	−.32*, .14
2. FFMQ total	−.070, .10	.00004, .034	.026, .085
Life events	.14, .14	−.026, .029	−.0014, .081
FFMQ × Life Events	.20, .11	.018, .035	−.060, .074

Note. Standardized coefficients shown. *SE* = standard error; FFMQ = Five Facet Mindfulness Questionnaire; IMP-I = Interpersonal Mindfulness in Parenting–Infant Version.
* $p < .05$.

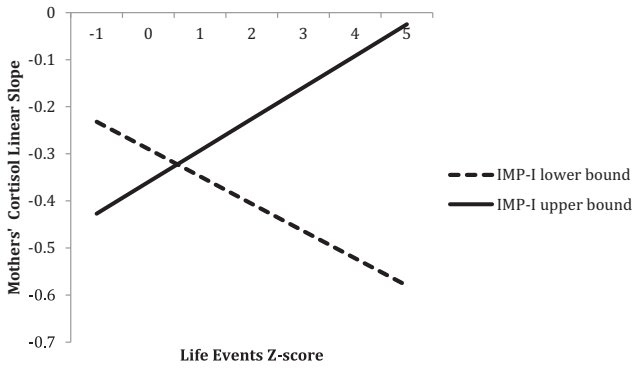

Figure 1. Maternal parenting-specific mindfulness interacts with life stress to predict mothers' cortisol recovery slopes (lines show effects of life events at the boundaries of the region of significance for mindful parenting scores—significant effects above upper boundary and below lower boundary).

the relationship with their infant, leading to more affectively negative interactions that, in turn, foster elevated infant cortisol. Further research will be needed to clarify behavioral mediators of such effects and whether these are especially important during the "stress hyporesponsive period" of HPA axis development (Lupien, McEwen, Gunnar, & Heim, 2009).

It is worth noting that infants of highly mindful mothers under low-life stress conditions also showed somewhat higher cortisol levels than their counterparts with less mindful mothers. Given that the former combination would be expected to offer a supportive developmental context in which sensitivity to environmental inputs is adaptive, it may represent the "sensitive" phenotype proposed by the biological sensitivity to context theory (Boyce & Ellis, 2005). As specified by this model, children growing up in a particularly protected and nurturing environment—such as the one offered by mothers high in mindful parenting—may actually benefit from the amplification of social signals offered by an easily activated HPA axis, leading to superior psychosocial adjustment. Again, further research exploring these effects alongside developmental outcomes in a wider range of rearing conditions will be needed to support or refute this idea.

For mothers, the nature of the mindful-parenting-moderated effect was quite different; when mothers were high in parenting-specific mindfulness, life events related to more extended cortisol responses (shallower recovery slopes). It appears that mothers who had experienced more early postnatal stress who were also more mindful as parents maintained higher cortisol during the SF interaction. Such prolonged HPA activation could represent heightened engagement with and/or sensitization to the infant's distress that benefits the infant (even if at a cost to the mother); this would fit with prior work associating maternal hypocortisol in a high-risk context with disrupted mother–infant communication (Crockett et al., 2013). This effect also underlines the proposal that mindfulness does not always reduce stress, but rather allows one to do what is needed, which sometimes involves feeling negative emotions—and experiencing their physiological effects—more strongly.

These findings highlight the potential for mindfulness to operate as an interpersonal process and offer a new lens for understanding research on stress-regulating mother–child interactions. Mothers who are more mindful in the parenting relationship may be more emotionally available, engaged with, and/or sensitive to their infants' cues—all characteristics that have been associated with lower concurrent or subsequent infant cortisol levels (Blair et al., 2008; Laurent, Harold, Leve, Shelton, & van Goozen, 2016; Philbrook et al., 2014). Even as these interactions help the infant to regulate, they may require the mother to maintain a higher level of effort and arousal in order to serve as the regulator; although research on older children has associated maternal sensitivity with greater parent–child physiological synchrony, some infant research suggests it is better for parent and child to exhibit complementary levels of stress system activation (Ostlund, Measelle, Laurent, Conradt, & Ablow, 2016). Within a mindful parenting frame, we might understand this phenomenon as the mother's open-hearted awareness of her infant's changing needs and ability to up- or downregulate her psychophysiological involvement accordingly.

Another perspective on differing mother versus infant effects has to do with the chronicity of stress exposure. High postnatal life stress could represent a continuation of accumulated stresses for the mother, as opposed to a relatively brief exposure for the infant. Given that chronic stress has been known to suppress HPA axis function, which, in turn, has been associated with health problems (Fries, Hesse, Hellhammer, & Hellhammer, 2005), mothers' mindful parenting-related maintenance of cortisol elevation during acute stress may signify an adaptive process. For their infants who are just learning to navigate a stressful environment, by contrast, it should be more beneficial to maintain lower cortisol levels (the "buffered" phenotype of the biological sensitivity to context theory). Research investigating the short- and long-term adjustment correlates of mindfulness-related cortisol elevations in the parenting context will be needed to better understand potential costs and benefits of the response patterns observed here, as well as elucidate intervention implications to support healthy functioning for mothers and infants.

Even as the current study takes an important step by expanding investigation of mindfulness in parenting to stress physiology, limitations in study design should be kept in mind and used to inform future research. The sample was relatively small and higher

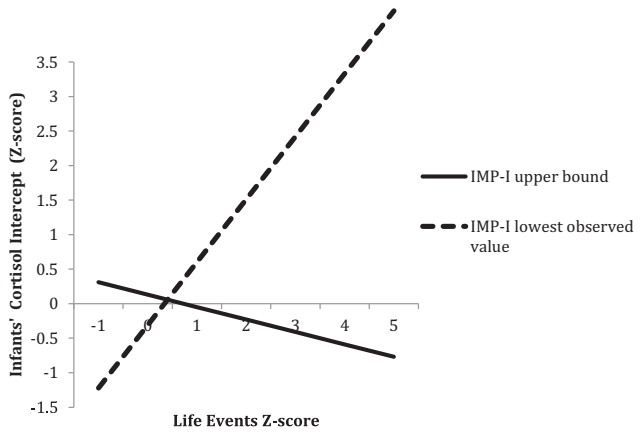

Figure 2. Maternal parenting-specific mindfulness interacts with life stress to predict infants' cortisol levels (line shows effect of life events at the upper boundary of the region of significance for mindful parenting scores—significant effects above upper boundary; marginal effect at lowest observed value).

risk than those in most parenting studies, even with the retention bias we found (i.e., the highest-risk/lowest-socioeconomic-status mothers dropped out at higher rates). The limited *n* restricts power, particularly for detecting interaction effects, and the effects noted here should be explored in larger samples with a range of sociodemographic characteristics to determine whether mindful parenting has stronger or weaker effects depending on the broader risk context. Relatedly, there were not enough mothers with mindfulness meditation experience to support statistical tests of possible differential effects for meditators versus nonmeditators; although not an aim of the current study, this issue should be explored in future research, as self-report mindfulness measures may reflect different things depending on meditation experience (Grossman, 2008).

The measurement of cortisol was limited to four saliva samples, the first of which occurred following entry into the lab (a stressor in itself), and the last of which was collected less than an hour after peak stress, restricting our ability to detect effects on the entire trajectory of reactivity and recovery. Given the importance of cortisol recovery for mental health outcomes (Burke et al., 2005), it will be important to examine effects of parenting-specific mindfulness using a more extended sampling protocol. Finally, although the longitudinal design offers indications of how mindful parenting may affect later parent/infant outcomes, there was no baseline assessment of cortisol to disentangle prospective effects from ongoing cross-sectional associations, and no experimental manipulation involved on which to base stronger causal statements. Research designs involving randomized controlled trials of prenatal or early postnatal mindfulness/mindful-parenting interventions will be informative in this regard. Finally, a full understanding of how the mindful parenting effects on stress noted here impact parent and child well-being will require more comprehensive investigation of behavioral mechanisms and psychological health outcomes.

The present investigation provides positive support for predictions that mindful parenting can shape stress responding in both parent and child not just at the subjective level but also at the level of biology. By supporting new mothers in the development of these qualities, we may be able to benefit generations to come.

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