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Mother-child adrenocortical synchrony; Moderation by dyadic relational behavior

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ABSTRACT

Mother-child adrenocortical synchrony, the coupling of cortisol (CT) secretion in mother and child, has been associated with shared parent-child experiences and maladaptive familial contexts. Yet, few studies tested adrenocortical synchrony in diurnal CT patterns. Guided by the bio-behavioral synchrony model, we examined whether mother-child relational behavior and maternal psychopathology may moderate the degree of concordance between mother and child's diurnal CT. Ninety-seven mothers and their six-year old children participated in two groups; mothers diagnosed with major depression disorder (N = 28) and non-depressed controls (N = 69). Mother-child interactions were observed and coded for dyadic reciprocity and dyadic tension and diurnal cortisol was collected from mother and child over two consecutive weekend days. Concordance between maternal and child's diurnal CT was found, significant above and beyond time of measurement. Maternal depression, while associated with attenuated child diurnal CT variability, was unrelated to adrenocortical synchrony. Higher child diurnal CT production predicted a stronger linkage between maternal and child's diurnal CT, suggesting that greater child physiological stress is associated with increased susceptibility to the influences of maternal stress physiology. Mother-child reciprocity was related to lower adrenocortical synchrony. Findings suggest that higher adrenocortical synchrony is associated with greater physiological stress and less adaptive dyadic relational patterns. Results raise the possibility that diurnal adrenocortical synchrony taps a unique aspect of HPA-axis functioning whose role in the cross-generational transfer of stress physiology requires further research.

1. Introduction

Cumulative evidence indicates that production patterns of the hypothalamic-pituitary-adrenal (HPA) axis hormone cortisol (CT) are coordinated between mother and child, and studies employed a variety of terms to describe this phenomenon, such as cortisol coregulation, hormonal concordance, stress contagion, or adrenocortical synchrony (Atkinson et al., 2013; Mörelius et al., 2015; Papp et al., 2009; Ruttle et al., 2011; Saxbe et al., 2014; Stenius et al., 2008). Most studies assessing mother-child CT concordance examined the coordination of CT following stress manipulations and found that when stress is experimentally elevated in either mother or child both partners increase CT levels in a coordinated fashion (Atkinson et al., 2013; Hibel et al., 2015; Mörelius et al., 2012, 2009; Neu et al., 2009; Ruttle et al., 2011; Sethre-Hofstad et al., 2002). In contrast, very few studies focused on the coordination of diurnal CT patterns between mother and child (Hibel et al., 2014; LeMoult et al., 2015; Papp et al., 2009; Schreiber et al., 2006; Stenius et al., 2008; Williams et al., 2013), a distinct aspect of HPA-axis functioning that is often uncorrelated with CT reactivity to momentary stressors (Edwards et al., 2001). As such, the mechanisms underlying mother-child diurnal CT concordance are largely unknown, particularly since this form of concordance may be associated with different factors from those linked with the coordination of phasic CT response. Since the consolidation of diurnal CT plays an important role in the development of children's stress response and aberrant diurnal CT patterns in childhood increase the risk for later psychopathology (Gunnar and Vazquez, 2001; Hart et al., 2009; Hastings et al., 2011), shedding further light on mother-child diurnal CT coordination may be of conceptual and clinical importance.

Several mechanisms may underpin the linkage between maternal and child's diurnal CT patterns, including genetic dispositions, shared environment, and learned behavior. One such pathway is charted by the *bio-behavioral synchrony* model, which posits that coordination between parent's and child's biological processes develops through online coordination of social behavior during moments of social contact

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(Feldman, 2016, 2007a). Bio-behavioral synchrony is a key feature of mammalian development that enables parent and young to mutually adjust physiological and social signals, permits the parent's mature physiological systems to externally-regulate the infant's immature systems, and provides an evolutionarily-adaptive mechanism to sensitize young to challenges in their environment (Feldman, 2015a, 2015b, 2012a, 2012b; Hofer, 1995; Stern, 1977). Research has shown that maternal physiological and behavioral systems dynamically adapt to the child's state, degree of system maturity, and ongoing risk signals from the environment and respond online to the infant's social cues (Feldman, 2015a; Hofer, 1995; Mogi et al., 2011). Similarly, studies have indicated that moments of mother-child behavioral synchrony are related to concordance in physiological systems, such as coupling of heart rhythms between mother and child (Feldman et al., 2011) or coordinated release of oxytocin (Feldman et al., 2010a). It is thus possible that adrenocortical synchrony in diurnal patterns may develop on the basis of cumulative moments of hormonal concordance when mother and child's CT production has been adjusted to fit the partner's current state. This hypothesis is supported by research indicating that diurnal CT concordance within the family correlates with the amount of shared experience (Mörelius et al., 2012, 2015; Schreiber et al., 2006; Stenius et al., 2008). For instance, preterm infants placed in family care and exposed to maternal-infant skin-to-skin contact exhibited CT concordance, while no correlations in CT were found among infants placed in standard incubator care (Mörelius et al., 2012, 2015). Six-month-old infants showed greater diurnal adrenocortical synchrony with their mothers as compared to their fathers (Stenius et al., 2008); in preschool-aged children mother-child morning CT levels were synchronized only on non-work days (Hibel et al., 2014); and among adolescents shared environment was a better predictor of afternoon CT linkage than genetic factors (Schreiber et al., 2006).

Differences in the amount of shared experience per se may not be sufficient to explain variability in adrenocortical synchrony, as mother-child pairs vary not only in hormonal linkage but also in the behavioral aspects of their relationship. The mother-child relationship is a central contributor to the development of children's HPA-axis functioning (Albers et al., 2008; Brummelte et al., 2011; Feldman et al., 2010b; Tu et al., 2007) and, thus, CT linkage may be related to the amount of reciprocal social interactions between mother and child. Studies in rodents indicate that the mother's species-adaptive behavior carries a unique effect on the consolidation of the pup's HPA reactivity, above and beyond the effects of nursing and maternal presence (Gubernick and Alberts, 1983; Rosenberg et al., 1970). Mothers with low corticosterone levels displayed more maternal behavior and their infants showed lower HPA-axis reactivity in adulthood (Francis and Meaney, 1999; Liu et al., 1997). Cross-fostering studies showed that maternal behavior exerted epigenetic effects on the pup's neural and behavioral response to stress, and these effects were found to override the effects of genetic dispositions (Champagne and Meaney, 2001; Kundakovic and Champagne, 2015). These findings not only provide evidence for the concordance between maternal and child's HPA-axis functioning and its lifetime implications but also suggest that variability in maternal caregiving may play a role in adrenocortical synchrony (Macrì et al., 2011).

Mother-child adrenocortical synchrony is a systemic construct; hence, at the behavioral level one should look for systemic features of the dyadic functioning as correlates. Two systemic constructs have been employed to define the dyadic atmosphere – dyadic reciprocity and dyadic negativity/tension – and both address the nature of the relationship rather than the behavior of one partner or the other. Dyadic reciprocity indexes the degree of coordination, synchrony, and mutual responsiveness in the mother-child system, whereas dyadic tension describes a relationship marked by heightened vigilance, negative effect, and anxiety. Longitudinal studies have shown that both styles are individually stable from infancy to adolescence (Feldman, 2010; Feldman et al., 2013a; Kochanska and Murray, 2000; Stright et al., 2008), suggesting that their associations with the child's HPA-axis functioning may relate to their consistency over time. Dyadic reciprocity has been associated with better vagal regulation during the still-face paradigm (MacLean et al., 2014; Moore and Calkins, 2004; Pratt et al., 2015), and more adaptive CT response to challenges in mother and child (Feldman et al., 2013b). Dyadic negativity/tension has been linked with poor emotion regulation (Cabrera et al., 2007), heightened CT response to stress, and lower CT variability (Albers et al., 2008; Brummelte et al., 2011; Feldman et al., 2010b; Tu et al., 2007).

Despite evidence showing that dyadic reciprocity and dyadic tension are associated with children's CT levels (Albers et al., 2008; Feldman et al., 2013b), no study, to our knowledge, examined their links with concordance in diurnal CT patterns. Studies assessing the relationship between maternal and family characteristics and the degree of mother-child CT linkage yielded mixed results. Some studies showed that sensitive mothers exhibit greater CT linkage with their children following induced stress (Atkinson et al., 2013; Hibel et al., 2015; Ruttle et al., 2011; Sethre-Hofstad et al., 2002). Others have shown that higher adrenocortical synchrony is observed in families with higher levels of maladaptive relationship patterns, such as partner violence and punitive parenting (Hibel et al., 2009), more negative affect between mother and child (Papp et al., 2009), and lower affective involvement within the relationship (Williams et al., 2013). Thus, the associations between mother-child interaction patterns and CT linkage are still not fully clear. One possible explanation may relate to the context in which CT linkage occurs. When individuals face external stressors that require immediate fight-or-flight response, mother-child CT linkage can be an adaptive mechanism aimed to signal danger to the child in a non-verbal manner. However, when the source of stress stems from intra-familial factors, higher adrenocortical synchrony may index over-activation of the *bio-behavioral synchrony* mechanism and may disrupt the mother's ability to soothe the child by reducing the linkage between her own stress response and that of the child's. Thus, dyads in which mother displays higher levels of the species-adaptive behavior may exhibit higher adrenocortical synchrony to acute external stressors but lower synchrony in daily CT production.

An additional factor potentially associated with adrenocortical synchrony is maternal psychopathology. In the presence of maternal stress-related psychopathology, synchronization of the stress response may induce vulnerability via the cross-generational transfer of stress physiology (Gunnar and Quevedo, 2007; McEwen, 1998). Studies have shown that when mothers employ maladaptive mechanisms for handling stress, the same non-optimal mechanisms are found in their children (Badanes et al., 2011; Bartels et al., 2003; LeMoult et al., 2015; Williams et al., 2013). One psychopathology that may be of interest in this context is maternal depression. Maternal depression has been associated with altered maternal CT patterns, including higher basal CT and reduced diurnal variability (Burke et al., 2005; Hankin et al., 2010). Exposure to maternal depression alters children's HPA-axis functioning and children of depressed mothers display higher basal CT levels (Brennan et al., 2008; Feldman et al., 2009; Halligan et al., 2004; Murray et al., 2010) and lower diurnal and reactive CT variability (Apter-Levi et al., 2016; O'Donnell et al., 2013), especially when maternal depression co-occurs with other risk factors (Badanes et al., 2011; Velders et al., 2012), such as greater dyadic negativity/tension and lower reciprocity (Apter-Levi et al., 2016; Feldman et al., 2009; Murray et al., 2010). Diurnal adrenocortical synchrony was found in mother-daughter pairs when the mothers were depressed (LeMoult et al., 2015), and CT linkage following a stressor was tighter between depressed mothers and their infants compared to controls (Laurent et al., 2011). Importantly, studies assessing the timing of maternal depression indicate that early (Essex et al., 2001) and chronic (Barker, 2013) depression pose the greatest risk.

As such, the current study assessed whether maternal depression and mother-child dyadic relational behavior moderate the degree of concordance between maternal and child's diurnal CT. We examined