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Fathers' cortisol and testosterone in the days around infants' births predict later paternal involvement

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ABSTRACT

Human paternal behavior is multidimensional, and extant research has yet to delineate how hormone patterns may be related to different dimensions of fathering. Further, although studies vary in their measurement of hormones (i.e., basal or reactivity), it remains unclear whether basal and/or reactivity measures are predictive of different aspects of men's parenting. We examined whether men's testosterone and cortisol predicted fathers' involvement in childcare and play with infants and whether fathers' testosterone and cortisol changed during fathers' first interaction with their newborn. Participants were 298 fathers whose partners gave birth in a UNICEF-designated "baby-friendly" hospital, which encourages fathers to hold their newborns 1 h after birth, after mothers engage in skin-to-skin holding. Salivary testosterone and cortisol were measured before and after fathers' first holding of their newborns. Basal and short-term changes in cortisol and testosterone were analyzed. Fathers were contacted 2–4 months following discharge to complete questionnaires about childcare involvement. Fathers' cortisol decreased during the time they held their newborns on the birthing unit. Fathers' basal testosterone in the immediate postnatal period predicted their greater involvement in childcare. Both basal and reactivity cortisol predicted fathers' greater involvement in childcare and play. Results suggest that reduced basal testosterone is linked with enhanced paternal indirect and direct parenting effort months later, and that higher basal cortisol and increases in cortisol in response to newborn interaction are predictive of greater paternal involvement in childcare and play, also months later. Findings are discussed in the context of predominating theoretical models on parental neuroendocrinology.

1. Introduction

Mammalian mothers experience a host of hormonal changes during pregnancy that prime maternal behaviors after giving birth (Mileva-Seitz and Fleming, 2011; Numan and Insel, 2003). In contrast, mammalian males do not experience the same physiological changes caused by pregnancy and lactation. However, among species in which fathers care for young, some changes in mammalian males' basal hormone levels during the transition to fatherhood are linked with paternal behaviors (Saltzman and Ziegler, 2014; Storey and Ziegler, 2016), and appear to be preparatory or experience-dependent (Numan and Insel, 2003). In particular, testosterone (T) has been widely studied in relation to paternal behavior (Gettler, 2014, 2016; Gray et al., 2017; Rilling, 2013) because of longstanding evidence documenting lower T in conjunction with monogamous mating and parenting effort in male birds (Wingfield et al., 1990). In humans, men transitioning to invested fatherhood experience declines in T, and lower T is associated with greater involvement in childcare (Gettler et al., 2011b). During their partners' pregnancies, fathers also experience declines in basal T, which are predictive of greater involvement in infant care (Edelstein et al., 2017) and partner investment (Saxbe et al., 2017).

Although T has been a central focus of the "hormonal basis of fathering" research, particularly in humans, other hormones such as oxytocin, vasopressin, and prolactin have been implicated in the nature of father-child bonding, such as father-child synchrony (Feldman, 2012c; Gettler, 2014; Gray et al., 2017; Rilling, 2013; van Anders et al.,

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2011), but less so in men's parenting *effort*, often operationalized in this literature as involvement in childcare (Abraham et al., 2014; Gettler et al., 2015). Cortisol (CORT) is an additional hormone that has been relatively under studied in relation to paternal behavior, but may relate to men's parenting effort. Short-term increases in CORT help to shuttle energetic resources to tissues throughout the body and enable cognitive and behavioral responses to stress (Sapolsky, 2000). Because caring for infants and young children is often described as highly stressful (e.g., with feelings of unpredictability and lack of control) and taxing (Brady and Guerin, 2010; Deater-Deckard and Scarr, 1996), parents' HPA axis is potentially often activated, which could have deleterious effects as a chronic exposure (see below), but may also play a role in reinforcing patterns of new behaviors to focus attention towards the infant. Indeed, mothers' elevated CORT in the postpartum period is positively associated with maternal approach behaviors and positive attitudes towards infants (Mileva-Seitz and Fleming, 2011) and greater interest in infant cues (Fleming et al., 1997). In this paper, we focus on how T and CORT may both predict fathers' involvement in childcare with infants and how T and CORT change during early father-infant interactions.

An unanswered question in understanding the role of hormones in paternal behavior is seemingly contradictory associations between paternal behaviors and basal and reactivity hormone measures, often operationalized as hormone changes during parent-infant interactions. For example, multiple studies have failed to find an association between basal T with parenting quality, but others have observed negative associations between T reactivity and parenting quality (Dorius et al., 2011; Endendijk et al., 2016; Kuo and Gettler, 2019; Kuo et al., 2016). Two different theoretical frameworks have been commonly used to model relationships between reactivity, and/or basal measures and paternal behaviors.

According to the biobehavioral synchrony model, hormonal and behavioral cues are exchanged during dyadic parent-infant interactions that create a pattern of behavioral responding (Feldman, 2012a, b). Specifically, biobehavioral synchrony between parent and infant develops via repeated exchanges of affective, physical, and gaze-matching behaviors, which correspond to matching of hormonal systems between parent and infant. Mothers benefit from preparatory physiological and hormonal changes and physical experiences during pregnancy to aid in the development of biobehavioral synchrony. Recent research suggests that for some fathers their physiology likewise begins to shift during their partners' pregnancies (Edelstein et al., 2017; Saxbe et al., 2017), raising intriguing questions about what might precipitate these changes, given fathers' more constrained sensory/physical connections with their unborn babies. That said, based on this conceptual model, it is held that fathers develop biobehavioral synchrony through experiences with the infant after the birth (Feldman, 2012a, b). Thus, within this theoretical perspective, men's hormone changes during early interactions with their infants may shape later patterns of paternal behavior. Although previous research has investigated whether fathers' T (Gettler et al., 2011a; Gray et al., 2007; Kuo et al., 2016; Storey et al., 2011) and CORT (Gettler et al., 2011a; Gray et al., 2007; Saxbe et al., 2014; Storey et al., 2011; Weisman et al., 2013) acutely respond to father-child interactions, whether these changes are associated with the patterning of later paternal behavior remains largely unanswered. One study showed that T decreases to a challenging lab-based father-infant interaction predicted subsequent positive paternal behavior within the same visit (Kuo et al., 2016). However, it is unknown whether reactivity relates to paternal behavior on a longer time scale, such as months.

While the biobehavioral synchrony model includes a focus on the influence of short-term hormonal changes on behavior (Feldman, 2012a, b), evolutionary-oriented theoretical frameworks, particularly life history theory (Gettler, 2014; Gray et al., 2017; Kuo and Gettler, 2019; Stearns, 1992), are commonly drawn on in studies of human paternal psychobiology to frame why men have the biological capacity to respond to invested partnering and parenting and what the functional implications are, from an adaptive perspective. According to life history theory, individuals must allocate limited resources (time and energy) to growth, reproduction, and survival, which are considered mutually-exclusive demands. As biological mechanisms that influence energetic allocation and behavioral processes, hormones help to mediate tradeoffs between demands within different life history strategies. Humans have evolved a life history strategy in which fathers commonly cooperate with mothers to raise young, which is atypical among mammals (Saltzman and Ziegler, 2014). Cross-species comparisons indicate it is likely that human male physiology has been adaptively selected to help promote parenting effort and shift fathers away from mating effort among committed males (Gettler, 2014; Rosenbaum and Gettler, 2018; Storey and Ziegler, 2016). For example, among vertebrate species that have evolved bi-parental care, higher T is generally linked to a mating-oriented strategy, while lower T is typically associated with a parenting-oriented strategy (Gettler, 2014; Gray et al., 2017; Kuo and Gettler, 2019; Saltzman and Ziegler, 2014; Storey and Ziegler, 2016; Wingfield et al., 1990). Both reactivity and basal shifts in endocrine function are commensurate with tenets of life history theory, including that hormonal shifts may precipitate functional behavioral changes, such as men's fathering behaviors during their transition to parenthood.

However, much of the research on human paternal physiology has focused on the relationships between basal hormone levels and paternal behavior, as indicators of longer-term, more stable shifts in behavior and the underlying physiology of men's life history strategies. Drawing on this framework, multiple studies have found that fathers with lower basal T engage in more childcare, and these patterns are commonly interpreted as reflecting prioritization of parenting effort over mating/competition (Alvergne et al., 2009; Edelstein et al., 2017; Gettler et al., 2015; Gettler et al., 2011b; Kuzawa et al., 2009; Mascaro et al., 2013). There are far fewer studies on basal CORT and paternal behavior but mothers' increased CORT is related to greater interest in infant odors (Fleming et al., 1997), positive maternal attitudes, and approach behaviors towards infants (Mileva-Seitz and Fleming, 2011). Elevations in basal CORT may reflect activation processes which help to orient parents towards infant care and engagement, although chronic CORT elevation could likewise have deleterious effects on parenting, through maladaptive facilitation of prolonged anxiety and other negative impacts on mental health (Erickson et al., 2003). Thus, the timing, duration, and context of elevated basal CORT production are likely critical considerations for the psychobiological effects on parenting.

To date, studies of human paternal psychobiology have often operationalized a range of fathering-related experiences (fatherhood status, time allocated to involvement in childcare, observed direct interaction with children, sensory exposure to infant cues) under the singular construct of “paternal behavior” without hypothesizing that different basal hormone and reactivity patterns may support different behavioral competencies within parenting contexts (van Anders et al., 2011). Here, we help to move the field forward by testing whether basal and reactivity hormone measures predict different dimensions of fathering behaviors, specifically, direct care, indirect care, and play.

In this paper we bridge two theoretical perspectives, biobehavioral synchrony (Feldman, 2012a, b) and life history theory (Gettler, 2014; Gray et al., 2017; Kuo and Gettler, 2019; Stearns, 1992), to examine whether short-term hormonal changes during early dyadic interactions and fathers' basal hormone levels predict their later involvement with their infants. Drawing on a large sample of U.S. fathers (N = 298), we first examined whether fathers experienced significant changes in T and CORT while holding their newborns for the first time. We hypothesized that T and CORT would decrease during holding, on average. Second, we assessed whether fathers' T and CORT reactivity to holding their newborns as well as basal levels during their infants' first day postpartum predict later paternal involvement (direct care, indirect care, and play). Based on life history theory, we hypothesized that greater paternal involvement would be predicted by lower basal T and higher basal CORT. Drawing on the feedback loop concepts proposed in the