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Relations Among Maternal and Paternal Behavior and Children's Stress Biology

S.K. Jiaming Lin
Scripps College

Stacey N. Doan
Claremont McKenna College

John Milton
Claremont McKenna College; Pitzer College; Scripps College

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S. K. Jiaming Lin

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Abstract

Parenting behavior has been shown to have a wide range of effects, influencing children's psychological and biological stress outcomes. Most research focuses on maternal parenting behaviors, with few studies observing the effects of paternal behaviors or the influence of both parents on their children. In this study, the relationship between maternal and paternal parenting behaviors was examined in its association to predict children's cortisol levels. Cultural differences in parenting styles was also observed. American (N=86) and Chinese (N=97) families participated in the study, with parents reporting their behaviors. Children's cortisol was collected during a stressor task and correlational analysis was conducted. Overall, cortisol levels were higher in Chinese children than in American children. Results indicated that across both cultures, only supportive paternal parenting was a significant predictor in children's cortisol levels. Additionally, there is a significant relationship within styles of parenting, indicating that mothers and fathers tend to have similar parenting styles.

Introduction

In recent decades, research has demonstrated that parenting has a wide range of effects. More recently, empirical data suggests that parental behavior not only influences children's psychological outcomes, but also shapes children's stress biology. A significant body of work has focused on cortisol, the end product of the hypothalamic-pituitary-adrenal (HPA) stress response system. Studies have demonstrated that , maternal "tactile stimulation," (Feldman, Singer, & Zagoory, 2010; Hostinar, Sullivan, & Gunnar, 2014) and mother-child attachment (Buss et al., 2012) dampens cortisol reactivity in children who are exhibiting fear (Feldman et al., 2010; M. R. Gunnar, Brodersen, Krueger, & Rigatuso, 1996; M. R. Gunnar, Brodersen, Nachmias, Buss, & Rigatuso, 1996; Megan R. Gunnar, Mangelsdorf, Larson, & Hertsgaard, 1989; Hostinar et al., 2014; Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996).

At the same time, there is a lack of literature that indicates the effects of paternal behavior on similar biological responses. Only a handful of studies have looked into how paternal behaviors affect the cortisol responses in children (Byrd-Craven, Auer, Granger, & Massey, 2012; Mills-Koonce et al., 2011). At the same time, past research has found that paternal behaviors are associated with emotional control and regulation, social functioning (Amato & Rivera, 1999), and cognitive development (Yogman, Kindlon, & Earls, 1995).

In sum, family relationships seem to influence the stress response by providing a form of social buffering and support, which in turn influence the activity of the HPA axis and cortisol production (Byrd-Craven et al., 2012). Hostinar et al. propose a model which postulates that "early social experiences shape the psychobiological efficacy of social support in containing HPA axis responses," illustrating the stress-dampening effects of social support. Other studies have shown how maternal presence during a stressful task lowers cortisol and increases oxytocin levels (Adams, Santo, & Bukowski, 2011; Seltzer, Ziegler, & Pollak, 2010). Additional studies have looked into early, positive interactions in parent-child dyads and how it could affect how the HPA axis responds to stressors throughout development into adulthood (Carlson & Earls, 1997; Gunnar, Morison, Chisholm, & Schuder, 2001). Results indicated that there is a clear biosocial relationship between parental behavior and adjustment of individual behavior on later social developments.

Studies have shown that there are long-lasting effects of developmental experiences, such as parenting, that can impact neuropeptide systems (Bales & Perkeybile, 2012). These systems are responsible for regulating stress through the release of various neuropeptides and hormones like ACTH, oxytocin, AVP, etc. and are important for managing emotional and social behaviors in children. There is a deficit in literature that studies the impacts of both parents on the cortisol stress-response in their children—as previously summarized, the majority of studies focus on mothering, and the few studies that have looked into fathering sought to find the sole influences that paternal behavior might have on the child. The goal of this paper is to understand how the influence of *both* maternal and paternal behaviors effect the stress biology of their children, with the hypothesis that harsher parental behaviors will act as predictor of higher cortisol levels in children during stressor tasks, while supportive parental behaviors will act as a predictor of lower cortisol levels. This paper also observes the role of culture in parent styles, and how that impacts the stress biology of children as well.

As the majority of developmental studies have a focus on the maternal impact, the goal of this paper is to understand how both maternal and paternal behavior can impact the stress biology of children. We organized our discussion as follows: first with a review on the science of stress, then an overview of studies that specifically looked into the effects of maternal and paternal behaviors in both human and animal models.

Background

The topic of stress is a widely studied area, beginning with the short paper published by Hans Selye in 1936 when he coined the term “general adaption syndrome,” later labelled as the “stress response” (Selye, 1936). In Selye’s original paper, he discussed the general biological response that people had to situations that caused “general alarm,” including the “triad of enlarged adrenal glands, lymph node and thymic atrophy, and gastric erosions/ulcers” (Selye, 1936; Szabo, Tache, & Somogyi, 2012). Events that cause stress reactions are called stressors (Selye, 1975), and the results of the stress input is known as the stress response (Hostinar et al., 2014).

Selye developed his idea of the “general adaption syndrome” (GAS) by breaking it down into three stages, where each stage has characteristics that are unique to it. The first stage is the “Alarm Reaction” (AR), the initial response to the alarming situation. Characteristics typically included in the AR are tissue catabolisms, gastro-intestinal erosions, hypoglycemia, and secretions from the adrenal cortex (Selye, 1950). The second stage of GAS is the “Stage of Resistance”, followed by the final “Stage of Exhaustion.’ Selye found that many of the initial biological reactions that occurred during the AR can be reversed during the stage of resistance; however, those can reappear during the stage of exhaustion. The three stages of GAS indicated that living organisms had the ability to adapt themselves to their changing surroundings (Selye, 1950).

Neurobiology of Stress:

The mechanics behind general adaption syndrome and stress-response can be understood through the "neurobiology of stress" (Hostinar et al., 2014). These responses mostly occur as a result of the biological activation of the hypothalamic-pituitary-adrenal (HPA) system and the autonomic nervous system. Stressors trigger a "neuroendocrine cascade that results in the production of glucocorticoids (GCs) through activation of the HPA axis"—cortisol in humans, and corticosterone in rodents (Cone, Low, Elmquist, & Cameron, 2003; Hostinar et al., 2014). The HPA axis has been associated with different brain regions, one of such is the parvocellular region of the hypothalamus (PVN). The PVN secretes corticotrophin-releasing hormone (CRH) and arginine vasopressin (AVP), which then trigger the release of adrenocorticotropic hormone (ACTH) from the anterior pituitary and send those hormones into circulation. The ACTH released from the anterior pituitary bind to receptors of the adrenal glands, in turn releasing GCs (M. Gunnar & Vasquez, 2006; Hostinar et al., 2014). Increased GC levels eventually lead to the inhibition of the HPA axis, following a negative feedback inhibition system.

Operating alongside the HPA axis are the limbic and cortical regions in the brain which include the amygdala, hippocampus, and prefrontal cortex (PFC). These regions help relay information about stressors or perceived threats that can stimulate or end a stress response (Hostinar et al., 2014). The amygdala is strongly tied to the autonomic stress system and is important for homeostasis, as well as emotional and stress integration. The central nucleus of the amygdala activates the HPA axis in response to stressors and integrates autonomic responses (Hostinar et al., 2014; Ulrich-Lai & Herman, 2009). The PFC is responsible for "executive functions," such as control of actions and thoughts, including memory, inhibitory control, and cognitive flexibility. These functions are important with regards to development of emotional and behavioral regulation (Hostinar et al., 2014; Zelazo, Carlson, & Kesek, 2008). It is primarily thought that the medial and ventral areas of the PFC regulate emotion through its connections to the amygdala, while the lateral and dorsal regions regulate thoughts and actions (Arnsten, 2009; Hostinar et al., 2014). These different regions in the PFC could contribute to the inhibition or stimulation of the HPA axis, as some studies conducted on rodents have shown, therefore effecting the stress response (Sullivan & Gratton, 1999).

Cortisol has many different effects on the body and has been demonstrated to be a reliable biomarker of HPA axis activity (Dickerson & Kemeny, 2004). In addition to being produced in response to a stressor, GCs are used on a regular basis to maintain hormone levels needed for motivation, energy, and general functioning (Hostinar et al., 2014). Studies have shown that the release of GCs follow the circadian clock, with increased levels in the morning shortly after waking up, while decreasing steadily throughout the day, reaching its lowest levels at night (Fries, Dettenborn, & Kirschbaum, 2009). However, repeated activation of the HPA response, such like that caused by chronic stress, can result in enhanced GC release throughout the day. Consistently elevated or low levels of GCs can impair physical and behavioral functions (Chrousos, 2009), which is crucial during developmental stages. Chronic stress also has repercussions in the cortical and limbic regions, which can inhibit the negative feedback system in the HPA axis (Hostinar et al., 2014).

Animal models:

There has been extensive research exploring the effect of social relationships as stress buffers in animals. The original identification of the neuroendocrine control of social buffering in infancy was found in squirrel monkeys; during separation, there was an increase in plasma cortisol in infants which reduced to normal levels after being reunited with the mother or after placement into a familiar environment (Coe, Franklin, Smith, & Levine, 1982; Coe, Mendoza, Smotherman, & Levine, 1978; Hostinar et al., 2014; Stanton & Levine, 1985). Rodent studies found that infant social buffering was not simply an immature version of adult social buffering, but was adapted to mother-infant dyads (Hostinar et al., 2014). Additionally, maternal deprivation studies in rodents illustrated how "maternal deprivation served to produce a state of chronic HPA hyper-responding," resulting in what could be viewed as a "state of chronic neuroendocrine stress"(Hostinar et al., 2014; van Oers, de Kloet, Whelan, & Levine, 1998).

"Stress diathesis" models suggest that interactions in early development, such as adversity or lower quality of parental investment, can impact the neural and endocrine system through increases in HPA axis responses to stress in adulthood (Meaney & Szyf, 2005; Repetti, Taylor, & Seeman, 2002). Such models also describe the interaction between development and possible epigenetic influences, including genomic variations (Bennett et al., 2002; Caspi et al., 2003; Meaney & Szyf, 2005). Epidemiological studies conducted on rats have demonstrated how maternal-infant interactions can cause structural changes in the DNA of the offspring, illustrating that even inherently stable genomic markers can be effected through environmental influences (Meaney & Szyf, 2005). Maternal interactions such as pup licking and grooming, as well as arched-back nursing were used as measures of maternal care. It was found that offspring's stress responses with mothers who facilitated high versus low maternal care behaviors had changes in DNA methylation, histone acetylation, and glucocorticoid expressions, indicating a direct relationship between maternal care differences and early development on behavioral and HPA responses on a biological level (Caldji, Diorio, & Meaney, 2003; Francis, Diorio, Liu, & Meaney, 1999; Meaney & Szyf, 2005).

Oxytocin levels through social buffering have also been a focus in animal models as it functions as a stress attenuator both directly and indirectly, as its role in behavior is diverse and similar across different species (Carter, 2003; Hostinar et al., 2014; Nelson & Panksepp, 1998; Onaka, 2004). Oxytocin knockout mice were found to have higher levels of corticosterone but lower levels of medial amygdala activity (Mantella, Vollmer, Rinaman, Li, & Amico, 2004), and prairie voles and rats had lowered HPA axis responses due to oxytocin release after social activity (Hostinar et al., 2014; Neumann, Krömer, Toschi, & Ebner, 2000; Windle, Shanks, Lightman, & Ingram, 1997).

Animal models first began to uncover the many different pathways that were impacted by social buffering. It is significant to recognize that many brain structures that mediate the attenuation of the stress responses is not fully developed in early life—both in animals and humans. However, a study conducted by Moriceau & Sullivan (2006) found that in rodents, 10-12 day-old pups had adult-like social buffering through measuring stress-induced corticosterone release (Hostinar et al., 2014; Moriceau & Sullivan, 2006). Further research has found that the relationship between rodent mothers and pups are mutual, as pups can also effect the mother's corticosterone levels—mothers experience a spike in their stress response while the pups are taken away for testing (Deschamps, Woodside, & Walker, 2003; Hostinar et al., 2014; C.-D. Walker et al., 2004). It is clear that levels of care on infants in animal models have greatly impacted oxytocin levels, which in turn influence the stress response and social buffering systems (Bales & Perkeybile, 2012; Carter, 2003; Hostinar et al., 2014).

Maternal and paternal influences on the stress response in human models

Animal models have laid the foundation for exploring how parenting affects the stress response. Current evidence suggest that parental behaviors greatly impact the development of a human brain, with particular focus on how children regulate their emotional and stress-response systems (Gunnar, 1998). According to the Early Life Stress Model, the type of caregiving experienced early in life regulates the activity of systems involved with stress management, which can later effect the development of systems that are involved with immediate stress-responses (Loman & Gunnar, 2010). Levine argued that “lack or loss of species typical parental stimulation is among the most potent stressors in early life” (Levine, 2005).

<u>Maternal Studies:</u>

The effects of maternal involvement on the HPA axis during early human developmental years has been well studied (Gunnar, 2006; Gunnar & Donzella, 2002), although there is a lack in literature that observe the effects during late childhood and adolescence (Hostinar et al., 2014). Studies have shown that infants in insecure-attachment relationships with their mother express higher cortisol levels in response to stressful situations compared those in secure-attachment relationships (Hostinar et al., 2014; Nachmias et al., 1996). Nachmias et al. suggest that securely attached infants have more coping resources, which predict lower cortisol responses; however, the effects of maternal buffering are limited to short periods of separation before cortisol levels begin increasing (Ahnert, Gunnar, Lamb, & Barthel, 2004).

Measures of caregiving begin to be associated with cortisol responses during infancy (Hostinar et al., 2014). Maternal interactions after taking a 3-month-old out of the bath was found to influence the “post-stressor cortisol recovery” in the infants, but not to the cortisol response to the change in temperature, as studies suggest that temperature might have “independent access” to the HPA axis (Albers, Riksen-Walraven, Sweep, & de Weerth, 2008; Hostinar et al., 2014; Walker, Scribner, Cascio, & Dallman, 1991). In 9-month-olds, a 30 minute separation from their mother elevates cortisol levels, however, being with a babysitter who is responsive to the infant during maternal absence dampens cortisol reactivity, demonstrating how people other than mothers can impact the stress biology of infants (Gunnar, Larson, Hertsgaard, Harris, & Brodersen, 1992; Hostinar et al., 2014).

Looking past infancy into early childhood, a longitudinal study found that maternal separation did not cause an increase in salivary cortisol in 9-month-olds, but did in 13-month-olds (Gunnar et al., 1989; Hostinar et al., 2014). Additional research on 18-month-olds and their mothers have indicated that secure attachment relationships and child temperament have a hand in predicting HPA axis responses, and have been replicated in similar studies (Gunnar, Brodersen, Krueger, et al., 1996; Gunnar, Brodersen, Nachmias, et al., 1996; Nachmias et al., 1996; Spangler & Schieche, 1998). These studies illustrate that maternal presence dampens cortisol reactivity, despite children physically reacting to fearful situations (Hostinar et al., 2014; Nachmias et al., 1996).

Maternal warmth during late childhood is another measure that has suggested impact on the stress regulation in young adults (Luecken, Hagan, Wolchik, Sandler, & Tein, 2016). A longitudinal study looked at child-reported levels of maternal warmth in families that were undergoing parental divorce during childhood, and found that perceived higher levels of maternal warmth during adolescence predicted lower cortisol levels in young adulthood after completion of a stressor task (Luecken et al., 2016). The effects of social buffering children between 7-12 years of age were also documented in the few experimental studies conducted (Adams et al., 2011; Seltzer et al., 2010). Specifically, females who had maternal interaction prior to the completion of a verbal stressor task expressed stronger cortisol dampening and higher oxytocin release post-stressor than girls who did not (Hostinar et al., 2014; Seltzer et al., 2010).

Other studies have looked into the effects of maternal parenting and psychological control on children’s stress response (Doan et al., 2017). Chinese and American mothers were assessed for amount of psychological control they exhibited by completed multiple questionnaires. Children’s salivary cortisol were collected before, during, and after completion of a stressor task. While the amount of psychological control that mothers exhibit towards their children varies, it was found that maternal psychological control was positively associated with higher levels of cortisol in children (Doan et al., 2017).

Similar to animal models, touch is a significant factor that dampens cortisol reactivity in human infants. One study found that 6-month-old infants whose mothers had provided “tactile stimulation” during a stressor event exhibited lower salivary cortisol levels and reduced cortisol reactivity (Feldman et al., 2010; Hostinar et al., 2014). In addition to decreased cortisol reactivity, tactile stimulation offers a plethora of beneficial effects, including enabling of calm states, lowering urinary cortisol levels, and regulating infant sleep patterns (Hostinar et al., 2014; Underdown, Barlow, & Stewart-Brown, 2010).

The influence of maternal stress on their child’s HPA axis and stress response is another area where research has been conducted, although there are few that link maternal stress in pregnancy to child stress during development. In healthy mother-child dyads, it was found that maternal cortisol levels during all stages of pregnancy effected the HPA axis volume and associated problems (Buss et al., 2012). More specifically, the higher levels of maternal cortisol, the larger the amygdala volume found in children at 7 years old, contributing to higher affective disorders, more so in females than males. This study suggests how early maternal behavior can begin influencing the HPA axis, as it has effects even prior to child birth.

Paternal Studies:

At the same time, humans are unique in that often fathers play a pivotal in children's development. The majority of literature regarding maternal impact on youth cortisol typically encompass "emotional" aspects of parenting such as warmth or punishment, and it is uncertain if emotional involvement is applicable to fathers. Fathers tend to interact with their children in more playful, physically stimulating interactions, whereas mothers tend to be regarded as caretakers (Cabrera, Fitzgerald, Bradley, & Roggman, 2014; Ibrahim, Somers, Luecken, Fabricius, & Cookston, 2017; Lamb, Pleck, Charnov, & Levine, 1985).

As the "traditional" roles of parenting are changing, father involvement during development has increased. Father involvement can be categorized into three main components: the first being interaction, the amount of time actually spent with children; secondly, availability, amount of time available to children; and thirdly, responsibility, the amount of care or arrangement of care for children that the father takes on (Lamb et al., 1985). National studies conducted in the 1970s found that fathers interacted with their children between a third and half the amount that mothers reportedly spent with their children (Lamb et al., 1985; Pleck, 1983); however, paternal availability was about half the amount of employed mothers (Lamb et al., 1985; Pleck, 1983; Quinn & Staines, 1977).

Research regarding residential parenting time in divorced families suggest that children have a correlated amount of emotional security with their fathers relative to the amount of time spent, leading to better quality father-child relationships and seemingly better physical health in adulthood (Fabricius & Luecken, 2007; Fabricius, Sokol, Diaz, & Braver, 2012; Ibrahim et al., 2017). A recent study conducted by Stevenson et al. (2014) indicated that the frequency of time parents spent interacting with their adolescent children predicted how important adolescents believed how much they mattered to each parent. Results found that the amount of time spent together and "perceived mattering" was stronger for fathers than for mothers (Ibrahim et al., 2017; Stevenson et al., 2014).

While there is a limited amount of research dedicated to addressing a link between paternal behavior and youth stress, other studies have found that negative fathering behaviors during developmental years have been related to dampened salivary alpha amylase (a biomarker of psychological stress) reactivity in adolescents, and increased cardiovascular activity in young adults (Lucas-Thompson & Granger, 2014; Roubinov & Luecken, 2010). Mills-Koonce et al. (2011) found that in response to a lab stressor, children who experienced more father negativity had higher cortisol response levels at 7 months and at 24 months, consistent with the idea that parental behavior shapes the HPA axis. Father involvement during infancy also influences cortisol reactivity at age seven, and was correlated with the development of mental health problems in later years (Boyce et al., 2006). Paternal behaviors also impact cortisol reactivity at later developmental stages; young adult women who reported having childhood or current negative father-daughter relationships had higher levels of cortisol reactivity during a lab stressor task (Byrd-Craven et al., 2012; Ibrahim et al., 2017).

Additional research looks to study how father involvement and the HPA axis are related, especially during a developmental period as important as adolescence. During adolescence, HPA reactivity and basal cortisol levels increase due to psychosocial performance stressors (Gunnar, Wewerka, Frenn, Long, & Griggs, 2009; Ibrahim et al., 2017). Adolescents also experience higher levels of stress as they encounter environmental challenges, as well as physical, social, and emotional changes which dramatically increases the incidence of mental health issues (Dahl & Gunnar, 2009; Ibrahim et al., 2017; Kessler, Chiu, Demler, Merikangas, & Walters, 2005). While adolescents tend to reallocate their time to their peers or significant others, parents still maintain an important role during this development (Hosley & Montemayor, 1997; Ibrahim et al., 2017). Fathers may be more accessible as a source of emotional support, but due to a wide variability in paternal involvement, fathers might be able to effect an adolescent's ability to manage transitions and developmental challenges, therefore influencing youth HPA axis and cortisol response (Eirini Flouri & Buchanan, 2002; Ibrahim et al., 2017; Williams & Kelly, 2005).

The potential role of culture

As society becomes increasingly diverse, it is important to consider how culture might influence father involvement. Cultural values have been associated with different patterns of paternal involvement based on studies that provided an ecological developmental perspective on parenting (Cabrera, Fitzgerald, Bradley, & Roggman, 2007; Ibrahim et al., 2017). Cruz et al. (2011) found that in families with Mexican backgrounds, involved fathers endorsed the belief that the role of the father in family is "culturally-prescribed" (Ibrahim et al., 2017). During infancy, Latino fathers demonstrated warmth and were more involved than Caucasian fathers, who tended to engage in child care (Cabrera, Hofferth, & Chae, 2011; Ibrahim et al., 2017). More recently, Ibrahim et al. (2017) conducted a longitudinal study with Mexican-American and European-American families to observe how frequency of paternal engagement with their adolescent children impacted cortisol stress-response levels in young adulthood, finding that increased frequency of father engagement predicted lower levels of cortisol in during young adulthood.

With the limited amount of data collected from existing paternal behavioral studies, there are additional factors that must be taken into consideration. Often times, paternal studies do not account for maternal behaviors when observing the effects of fathers on their children; however it would be necessary to do so in order to identify the distinctive effects of paternal behaviors (Ibrahim et al., 2017; Marsiglio, Amato, Day, & Lamb, 2000). It is important to consider maternal involvement as it might influence paternal involvement, in addition to how the amount of fathering that occurs may be attributed to co-parenting (E. Flouri, 2008; Ibrahim et al., 2017; Stevenson et al., 2014).

Methods & Materials

Participants:

Families from the suburban areas in Beijing, China and from a Midwestern United States town were recruited through local pre-schools. For a total of 97 mother-child dyads in the study, 44 children from the United States (25 girls, *M* age=54.07) and 59 children from China (33 girls, *M* age=52.42) participated. The fathers (*N*=86) were also recruited using the same methods, yielding 86 father-child dyads of the same distribution. An additional, fourteen children were excluded due to conditions that would impact the cortisol levels (i.e. medications, asthma). Children of Asian descent in the American sample were also excluded. The American mothers (*N*=41) included five African-Americans and two that did not report ethnicity or race. There were fewer American father participants (*N*=36) than there were Chinese (*N*=50). All children came from a middle-class economic status, with the majority of mothers having received a college education.

Procedures:

A packet of questionnaires was completed by parents on family background characteristics, parenting styles, and both children's and parent's emotional and behavioral functioning. Questionnaires were translated and back-translated by two bilingual English-Chinese speakers, in addition to being checked by both native English and Mandarin speakers to certify that there was equivocal translation.

Rooms at their preschools or a child-friendly laboratory were used to test the children. To induce a stress response, a mild stressor was introduced through a computer game that became increasingly difficult as the participant progressed, until it became impossible to win. Once the game ended, a loud buzzer sounded and a "frowny" face icon appeared on the screen, indicating that the participant had lost the game. Initially, the experimenter played the game with the participant, while the game was in a special “no-lose” mode, rendering it impossible to fail. After the child won, the game was restarted and changed to the “no-win” mode. The child was left alone to play the game, and was instructed that they would receive a prize if they won. Sixty seconds after the end buzzer sounded, the experimenter returned to the room and expressed concern once the child responded no when asked if they had won the game. A second experimenter then entered the room to explain that the game was broken. The initial experimenter then told the child that they had done a great job and would have won the game had it not been broken and then allowed the child to have the option of choosing a prize.

Measures:

Parents completed the Socialization of Moral Affect questionnaire-Preschool Parent (SOMA-PP; Denham et al.,1997). The SOMA presents parents with hypothetical situations involving child behavior, and parents are asked to rate the likelihood that they would employ different behavioral responses on 1- (“Not at all likely”) to 5- (“Very likely”) point scales. The SOMA has shown good reliability and predictable correlations with similar measures provided by the same informant (Rosenberg, 1997). To improve the cross-cultural validity of this scale, the original English version was given to a separate set of Hong Kong and Beijing parents of preschoolers with open-ended answers. Several of the more frequent of these were incorporated into the final version of the scale and minor cultural modifications of the instruments were also made. Positive behaviors include supportive behaviors (e.g. help child check school bag), encouragement, and teaching (e.g., encouraging child to think about consequences of behavior), whereas negative parenting included four subscales assessing love withdrawal, power assertion, public humiliation and corporal punishment. Gender, time, and age of participants were all controlled for as well.

<u>Cortisol:</u>

Salivary cortisol was collected by trained research assistants using Salivettes (Salimetrics, LLC State College, PA). Multiple samples were collected throughout the visit, the first was taken once the participant arrived to the testing site. After a 30 minute play session, the second sample was collected at time 0 to serve as a baseline. Samples were then obtained in intervals of 10 minutes during the first hour, and then at 75 and 90 minutes after the stressor task. Unflavored dental cotton rolls were used to absorb saliva by gentle chewing for 60 seconds. Within 24 hours after collection, saliva samples were refrigerated and centrifuged at 3000 rpm for 5 minutes. Samples were then stored at -20C until cortisol concentration was assayed in duplicate using commercial kits (High Sensitivity Salivary Cortisol Enzyme Immunoassay Kit, Salimetrics, LLC State College, PA) at both testing locations. Inter-assay variability was calculated to be less than 5% at both locations, and ten saliva samples were assayed in both testing sites to determine inter-site variability. There were no systematic variation in cortisol levels between the two study locations.

Missing data for cortisol responses (1.5%) was due to some participants having incomplete data in different tasks. Analyses was conducted with the complete data set and imputed missing values, which were included using the IVEWARE24 SAS macro and regression model. Cortisol data was log transformed to improve normality for imputed values and converted back to original scale after imputation. Imputation was performed separately for China and the United States due to overall differences in the mean cortisol values.

Results:

Preliminary analyses:

We first examined relationships among demographic variables and our variables of interest in the entire sample. Maternal education and paternal education was negatively correlated with parenting styles across cultures (maternal supportive, $r(97) = -0.238$, $p < 0.05$; harsh $r(97) = -0.297$, $p< 0.01$; paternal supportive, $r(86) = -0.251$, $p < 0.05$; harsh $r(86) = -0.315$, $p < 0.01$). There were also sex differences on father's parenting style, with Chinese fathers reporting higher levels of supporting parenting $t(84) = 2.20$, $p = 0.03$. Additionally, age in both American ($M = 54.07$, SD=4.707) and Chinese ($M = 52.42$, $SD = 3.318$) samples was not found to have a significant correlation with parenting styles in either mothers or fathers ($p > 0.05$).

Thus, parental education, child sex, and age, as well as time of day (as is typical in cortisol studies due to the diurnal rhythm of cortisol) were controlled in substantive analyses. See Table 2 for all correlations of variables across both samples.

Table 1.
Means and standard deviations of variables by culture

	American			**Chinese**		
	N	M	SD	N	M	SD
Age (months)	44	54.07	4.707	59	52.42	3.318
Supportive Fathers**	36	3.489	0.525	50	4.023	0.401
Harsh Fathers**	36	1.835	0.560	50	2.538	0.560
Supportive Mother**	41	3.616	0.474	56	4.247	0.279
Harsh Mother**	41	1.718	0.469	56	2.600	0.520
Cortisol levels**	44	1.586	0.451	59	2.078	0.539

*p < 0.05 **p < 0.01

Cultural differences in parenting styles and children's cortisol:

See Table 1 for all means and standard deviations. Two-tailed t-tests were conducted to test for the significance between parenting styles and culture. Data suggests that there was a significant difference ($p < 0.01$) between the two cultures, with Chinese children having overall higher cortisol levels (M = 2.078, SD = 0.539) than American children (M = 1.586, SD = 0.451). Chinese mothers scored significantly higher (M = 2.600, SD = 0.520, $p < 0.01$) than American mothers in harshness (M=1.718, SD = 0.469), and also in supportive behaviors (Chinese, M = 4.247, SD = 279; American, M= 3.616, SD = 0.474; $p < 0.01$). Chinese fathers (M = 4.023, SD = 0.401) scored significantly higher ($p < 0.01$) than American fathers (M = 3.489, SD = 0.525) in supportive behaviors; however, there was no significant difference for harsh behaviors between American (M = 1.835, SD = 0.560), and Chinese fathers (M = 2.538, SD = 0.560).

Table 2. *Correlations for variables across both samples*

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Age	-	-0.043	-0.051	0.073	-0.078	-0.070	-0.030	-0.146
2. Maternal Education		-	0.632**	-0.256*	-0.370**	-0.238*	-0.297**	-1.88*
3. Paternal Education			-	-0.251*	-0.315**	-0.013	-0.102	-1.58
4. Supportive Father				-	0.557**	0.502**	0.356**	0.083
5. Harsh Father					-	0.395**	0.592**	0.336**
6. Supportive Mother						-	0.479**	0.204*
7. Harsh Mother							-	0.392**
8. Cortisol Levels								-

*p < 0.05 **p < 0.01

Correlation analyses across all variables for both samples was conducted (see Table 2 for all correlations). Maternal education in both cultures was found to have a significant negative correlation with cortisol levels ($r(97) = -1.88$, $p < 0.05$). Paternal education did not have a significant correlation with cortisol levels ($r(86)=-1.58$, $p > 0.05$). Additionally, there was a significant positive correlation between harsh parenting and cortisol levels (mothers, $r(97) = 0.392$; fathers, $r(86) = 0.336$, $p < 0.01$), as well as in supportive maternal behaviors and cortisol levels ($r(97) = 0.204$, $p < 0.05$). There were also significant positive correlations between similar parenting styles in mothers and fathers, for both harsh behavior ($r(183) = 0.592$, $p < 0.01$) and supportive behavior ($r(183) = 0.502$, $p < 0.01$).

Table 3

Correlations among all variables measured by ethnicity

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Age	-	0.101	0.068	0.203	0.207	-0.068	-0.226	-0.230
2. Supportive Father	0.190	-	0.441**	0.359*	0.159	-0.014	-0.090	0.012
3. Harsh Father	-0.102	0.362**	-	0.175	0.513**	0.174	-0.007	-0.165
4. Supportive Mother	-0.173	0.109	-0.018	-	0.120	-0.033	-0.016	0.099
5. Harsh Mother	0.058	-0.111	0.285*	0.070	-	0.377*	0.015	-0.071
6. Cortisol levels	-0.084	-0.330*	0.80	-0.212	0.022	-	0.007	-0.091
7. Maternal education	-0.061	-0.220	-0.017	0.004	-0.127	-0.048	-	0.651**
8. Paternal education	0.050	-0.275	-0.256	0.121	0.003	-0.123	0.625**	-

American above diagonal, Chinese below diagonal

*p < 0.05 **p < 0.01

Table 3 reports correlations among all variables by ethnicity. Age had no significant correlations with other variables. In the American sample, there was a significant positive correlation between supportive fathers and supportive mothers ($r(77) = 0.359$, $p < 0.05$), as well as between harsh mothers and cortisol levels ($r(97) = 0.377$, $p < 0.05$). There was a significant positive correlation between supportive and harsh fathers in both the American ($r(36) = 0.441$, $p < 0.01$) and Chinese ($r(50) = 0.362$, $p < 0.01$) samples. Additionally, harsh mothers and fathers both had significant positive correlations, with American parents having a stronger correlation ($r(77) = 0.513$, $p < 0.01$) than Chinese parents($r(106) = 0.285$, $p < 0.05$). Supportive fathers and cortisol levels also had negative correlations, but was only significant in Chinese fathers ($r(50) = -0.330$, $p < 0.05$).

Table 4.

Regression analysis for variables predicting children's cortisol levels

	B	**Std. Error**	**Beta**	**t**	**Significance**
Model 1					
Constant	3.196	1.047		3.052	0.003
Maternal education	-0.034	0.080	-0.065	-0.423	0.674
Paternal education	-0.005	0.072	-0.009	-0.067	0.947
Sex	-0.145	0.124	-0.134	-1.175	0.244
Age	-0.019	0.016	-0.138	-1.216	0.228
*Culture***	0.396	0.144	0.352	2.753	0.008
Time	-2.783E-6	0.000	-0.056	-0.491	0.625
Model 2					
Constant	3.423	1.080		3.170	0.002
Maternal education	0.016	0.080	0.031	0.201	0.842
Paternal education	-0.063	0.075	-0.123	-0.843	0.402
Sex	-0.157	0.122	-0.145	-1.292	0.201
Age	-0.021	0.016	-0.148	-1.303	0.197
Culture	0.379	0.199	0.337	1.903	0.062
Time	-8.156E-6	0.000	-0.165	-1.389	0.170
*Supportive Father**	-0.352	0.158	-0.335	-2.234	0.029
Harsh Father	0.087	0.136	0.100	0.642	0.523
Supportive Mother	0.198	0.134	0.237	1.474	0.146
Harsh Mother	0.052	0.166	0.047	0.311	0.757

*p < 0.05 **p < 0.01

Relations among parenting styles and children's cortisol:

Hierarchical linear regressions were used to examine the contribution of paternal and maternal parenting styles on children's cortisol levels. All parenting variables were mean centered. All models controlled for culture, parental education, child sex, and age at testing. In addition, since cortisol has a diurnal rhythm, we controlled for time of data collection. Results suggest that of all the parenting variables, only supportive paternal parenting was a significant predictor of children's cortisol (β=-0.335, SE = 0.158, p = 0.029). See Table 4 for results of the linear regression models. Exploratory analyses were ran to examine the extent to which culture and child sex moderated the effects of parenting style on children's cortisol. None of the interaction terms were significant.

Discussion

The relationship between maternal and paternal interactions and their children's stress biology was investigated through measurement of child salivary cortisol levels during a stressor task and completion of surveys by parents. The hypothesis of this study was that harsher parental behaviors will act as predictor of higher cortisol levels in children during stressor tasks, while supportive parental behaviors will act as a predictor of lower cortisol levels. Results indicated that supportive paternal parenting yielded significantly different negative correlations with cortisol in comparison to supportive maternal parenting. Overall, cortisol levels were higher in Chinese children than in American children.

The findings of this study are consistent with both animal and human models that illustrate the influence of maternal behavior on the regulation of HPA axis functioning (Coe et al., 1982; Doan et al., 2017; Hostinar et al., 2014; Meaney & Szyf, 2005). In addition, these findings endorse how the parent-child relationship contributes to the development and management of the stress response (Doan et al., 2017; Gunnar et al., 2009; Hostinar et al., 2014).

The data suggests that there is a significant relationship within styles of parenting, indicating that mothers and fathers tend to have similar parenting styles, which is not uncommon. Additionally, educational background across cultures seem to have a significant influence on parenting styles in both mothers and fathers. When observed by group, maternal education was negatively correlated with parenting behaviors in Chinese mothers, but positively correlated in American mothers. This suggests that education contributes to parenting styles by balancing out the amount of support or harshness that mothers display to their children, rather than increasing one or the other.

Cultural influences on the relationship between parenting and child development it a debated topic in literature. A previous study found that cultural measurements on parenting styles typically used in studies on Caucasian families yielded inconclusive results in families of Chinese backgrounds, leading to an ornithological approach to measuring parenting (Lim & Lim, 2003). Another study on Mexican families and non-white-Hispanic families found that cultural variances in parenting could be based on ecological influences rather than culture itself (Varela et al., 2004). Child emotion-regulation, which is closely tied to the HPA axis, was also found to be impacted by child-parent relationships. Kiel and Kalomiris (2015) concluded that culture does influence parenting relevant to emotion-regulation, which develops from the parent-child relationship. It was also found that fathers' influence became more pronounced across development (Kiel & Kalomiris, 2015), a reason that could explain why only supportive paternal parenting seemed to predict child cortisol in early developmental stages.

The significance of supportive paternal parenting in predicting child cortisol levels could have been associated with the limitations of the study regarding the nature of self-reporting surveys completed by parents, in addition to the small number of paternal participants. It is also important to consider that the study was both cross-sectional and observational, therefore it is possible that parenting styles may change over time in a way that it could predict or influence child cortisol levels. Furthermore, while previous studies with the same sample yielded similar results (Doan et al., 2017; Grabell et al., 2015), it is possible that children respond differently to certain types of stressors. Lastly, it is likely that child emotions and responses may also affect parenting styles, suggesting bi-directionality between parenting and child responses (Kiel & Kalomiris, 2015).

While the effects of parenting styles on children range, it can be concluded that parenting behaviors do and can act as a predictor in child cortisol levels. Mothers and fathers tend to engage in similar parenting styles; however, when both parental behaviors are taken into consideration in observing the stress response in their child, only supportive paternal behaviors have significant effects.

Future studies could look into why there is a difference in parental impact on child cortisol levels, such as specifically why supportive paternal parenting influenced child cortisol while neither maternal parenting style did to a significant extent. Similarly, it would be interesting to understanding why supportive paternal parenting predicted child cortisol levels, while harsh paternal parenting did not. One possibility may be that harsh parenting is generally low. The results are likely to be very different when looking at high levels of abuse and neglect. Additionally, as families are becoming more diverse, it would be important to also understand how parenting styles in same-sex or single-parent families could impact child cortisol, in addition to how single culture or bicultural parents might influence parenting styles.

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