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Social deprivation and the HPA axis in early development

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Summary Growing evidence suggests that early social deprivation impacts the activity of the hypothalamic—pituitary—adrenocortical axis. Early adverse care in the form of institutional or orphanage care provides a human model for early social deprivation. The present study examined changes in diurnal cortisol during the transition to family care in the first 2 years post-adoption. Children adopted between 15 and 36 months from institutional care were examined four times during their first 2 years post-adoption ($N = 58$). Comparison groups included same-aged peers reared in their birth families ($N = 50$) and children adopted during their first year from overseas foster care ($N = 47$). Children provided daily cortisol samples at roughly 2, 9, 17, and 25 months post-adoption. Post-institutionalized and post-foster care children exhibited less steep diurnal cortisol compared to non-adopted same-aged peers; these differences did not diminish across the 2 year period. For post-institutionalized children, lower social care quality in institutions was associated with less steep cortisol slopes. Lastly, shallower diurnal cortisol was a mediator between adoption status and increased behavioral problems 2 years post-adoption. Consistent with the non-human primate literature, early social deprivation may contribute to early programming of the HPA axis.

1. Introduction

There has been a long-standing interest in the impact of early social deprivation on activity of the hypothalamic—pituitary—adrenocortical (HPA) axis. In rodent models, social deprivation induced by prolonged separations of pups from the dam increases the reactivity of the HPA axis through epigenetic modifications in the glucocorticoid gene (Meaney and Szyf, 2005). While rodent

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models are useful, studies of non-human primates are sometimes more informative because of their greater similarity to humans. In non-human primates, while results are not entirely consistent (Dettmer et al., 2012), early social deprivation appears to down- rather than up-regulate the HPA axis (Meyer et al., 1975; Clarke, 1993; Cirulli et al., 2009). This was confirmed recently in a large study of Rhesus macaques (Hawkley et al., 2012). The results demonstrated that socially depriving infant monkeys (i.e., nursery rearing) resulted in smaller HPA responses to stressors and pharmacological challenges. Notably, HPA activity normalized with increasing social stimulation through early peer experiences. Thus, far from being hyper-active, in rhesus monkeys early social deprivation reduced the HPA set point and reactivity.

Children reared in orphanages or similar institutions provide a human model of early social deprivation. Studies of HPA axis activity in these children have yielded mixed results, perhaps because social deprivation is typically confounded with physical deprivation, malnutrition, pathogen exposure and abuse, which may also impact the HPA axis. Despite heterogeneity across institutions, institutional rearing nearly uniformly involves fewer supportive adult—child interactions than most family contexts (Smyke et al., 2007; van IJzendoorn et al., 2011). Toddlers living in an orphanage in Romania were found to exhibit lower morning and slightly elevated evening cortisol levels (Carlson and Earls, 1997); however, preschool-aged children in a Ukrainian institution exhibited normal diurnal rhythms, although those who had been growth-stunted had elevated levels (Dobrova-Krol et al., 2008). The remaining studies have been conducted with children adopted out of institutional care (post-institutionalized, PI). One report on Romanian PI children noted higher cortisol levels over the day, even though children had been in their adoptive families for 6 years or more (Gunnar et al., 2001). All other studies comparing PI to non-adopted children have noted either lower morning cortisol or less marked diurnal rhythms (Gunnar and Vazquez, 2001; Johnson et al., 2011). Similar findings emerged for children in foster care, particularly if they experienced severe early neglect (Bruce et al., 2009). One study followed internationally adopted individuals into adulthood and found that those who were severely neglected prior to adoption had lower morning cortisol and a less marked decrease in cortisol over the day (van der Vegt et al., 2009).

The goals of the present study were threefold: (1) to examine changes in children's HPA axis activity following adoption, (2) to examine aspects of preadoptive care that may contribute to individual differences in HPA activity, and (3) to examine individual differences in HPA activity in contributing to problem behavior. The majority of studies of the HPA axis in deprived children have either examined them during periods of deprivation or years following removal from these conditions. Little is known about changes in HPA activity as the child transitions from institutional to family care. One study did examine Eastern European children ranging from 7 to 30 months of age at adoption; children's cortisol was assessed at 1 and 6 months post-adoption and found that the diurnal decrease in cortisol became more robust over that time (Kroupina et al., 2012). However, as that study did not include a sample of non-adopted children we do not know whether all children show increases in the robustness of the rhythm during the same age period. One purpose of this study was to examine changes in diurnal cortisol patterns of PI children over the first 2 years in the adoptive home and compare them to cortisol trajectories in age-matched non-adopted children. Given the literature on PI children and non-human primates, we expected that the diurnal cortisol slope would be flatter at adoption but become more robust with time spent in the family. However, we expected that the most socially deprived PI children might continue to show a flatter cortisol slope and/or lower morning cortisol even after 2 years in their new homes.

Children reared in overseas orphanages experience a wide variety of deprivation. In addition to examining change in children's HPA axis functioning following adoption, the present study sought to examine factors that may contribute to individual differences in any changes that might be observed. The present study examined the role of duration of institutionalization, variations in physical and social care quality, and growth-stunting. Growth-stunting at adoption has been associated with disruptions in diurnal cortisol following adoption. Kroupina et al. (2012) noted that it was the growth-stunted children who exhibited the most depressed diurnal rhythm at adoption and the greatest change over time. In addition, Johnson et al. (2011) reported that, years after adoption, children who had been growth-stunted at adoption continued to exhibit an altered diurnal cortisol pattern compared to non-adopted children and children who had not been growth-stunted at adoption. Kertes et al. (2008) also noted an association between growth stunting and altered HPA activity 6 or more years after adoption among PI children.

Children adopted from institutions are at heightened risk for numerous behavior problems, including problems with emotion and behavior regulation (Gunnar and van Dulmen, 2007; Colvert et al., 2008; Bos et al., 2011). A third purpose of the present study was to examine whether individual differences in diurnal HPA activity contributed to individual differences in behavioral problems. More specifically, patterns of daily HPA axis activity were examined as a mediator of the relation between early social deprivation and problem behavior. This study focused on children adopted from institutions between 15 and 36 months of age, which is both a common adoption age and late enough that most studies of similarly aged adopted children find a significant percentage of them exhibiting cognitive and emotional difficulties (Zeanah et al., 2011).

In this study we employed several comparison groups. First, we compared PI children to non-adopted children born and raised in families of similarly high socioeconomic status as those who adopt internationally. To disentangle the effects of deprivation due to institutional care from those of broader experiences of deprivation and disruption in early care, we employed a second comparison group of children adopted internationally from foster care. While children adopted from foster care experienced more home-like pre-adoption care, they also experienced several disruptions in early care like the PI children. Some countries largely employ foster care to house wards of the state, while others rely on institutions to care for the same type of children. Whether a child ends up in foster care or institutional care depends primarily on where they live