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The developmental course of salivary alpha-amylase and cortisol from 12 to 36 months: Relations with early poverty and later behavior problems

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Summary This study examined the development of baseline autonomic nervous system (ANS) and hypothalamic—pituitary—adrenal (HPA) physiological activity from 12 to 36 months as well as antecedents (poverty) and consequents (behavior problems) of individual differences in physiological development. Children ($N = 179$; 50% poor; 56% African American; 52% male) provided saliva samples at 12, 18, 24, 30, and 36 months of age. Latent growth curve models indicated that nonlinear change was evident for both sAA and cortisol, with sAA increasing and cortisol decreasing with age. Children residing in poor households exhibited lower initial levels of sAA, but not cortisol. African-American children showed slightly smaller decreases in cortisol over time. Initial levels of sAA predicted higher levels of internalizing behaviors at 36 months and both initial levels of and total change in sAA predicted higher levels of externalizing behaviors at 36 months. There was no evidence that sAA or cortisol mediated the relationship between poverty and later behavior problems.

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The first years of life are a formative period for the development and calibration of stress response systems (Anisman et al., 1998; Cicchetti and Walker, 2001; Gunnar and Cheatham, 2003). Individual differences in the ability to manage stress likely mediate the effects of adversity on the development and the expression of children's problem behavior (see Johnson et al., 2013; Shonkoff et al., 2012 for reviews). This study will focus on the autonomic nervous system (ANS) and the hypothalamic—pituitary—adrenal (HPA) axis, two systems that play an important role in physiological and behavioral self-regulation (Gunnar and Quevedo, 2007).

1. Development of physiological systems in early childhood

Measurement of HPA-axis activation can be achieved non-invasively using a well-established and validated salivary analyte, cortisol, the main glucocorticoid secreted throughout the body (Kirschbaum et al., 1992; Schwartz et al., 1998). Numerous studies have established that salivary alpha-amylase (sAA), an enzyme released from the salivary gland, serves as a non-invasive and an easily obtained surrogate marker of ANS activity in adults and children (see Granger et al., 2007; Nater et al., 2005; Nater and Rohleder, 2009; Rohleder and Nater, 2009). Other studies have indicated that sAA is specifically a measure of sympathetic (SNS) activation. For example, it has been demonstrated that sAA levels can be suppressed by the administration of an adrenergic blocker propranolol (Granger et al., 2007; van Stegeren et al., 2006) and sAA is related to catecholamine levels in the bloodstream (Chatterton et al., 1996; Nater et al., 2006).

A small number of cross-sectional studies have examined patterns of sAA and cortisolic activity in early childhood. Davis and Granger (2009) assessed developmental differences in sAA levels at baseline and after well-baby inoculations at 2, 6, 12, and 24 months of age. Baseline levels of sAA increased from 2 to 24 months, and stress related increases in sAA were evident at 6 and 12 months of age, but not at 2 or 24 months of age. Other research from the field of oral biology and dentistry, suggests that sAA may continue to increase throughout early childhood, not reaching adult levels until 3—5 years of age (O'Donnell and Miller, 1980). Baseline cortisol levels show an opposite pattern, decreasing through 36 months of age (Watamura et al., 2004), possibly as a result of maturing circadian rhythms and sleep patterns (Gunnar et al., 1996). However, to date, the development of sAA and cortisol has not been assessed longitudinally in the same sample.

2. Associations among poverty, stress and behavior problems

Evidence relating early life adversity, such as poverty, to the activity of the ANS and HPA axis, has been mixed. While low income has been linked to increased diurnal levels of cortisol among infants (Saridjan et al., 2010) and higher basal levels among preschoolers (Blair et al., 2005), other studies have found no or mixed associations between poverty and cortisol (see Dowd et al., 2009). And while cross-sectional studies have pointed to poverty affecting epinephrine (but not norepinephrine) levels in older children (Evans and English, 2002), the literature on sAA and poverty is limited. One study suggested that children from low SES backgrounds show higher levels of sAA (Granger et al., 2006), whereas another revealed no link between low income and sAA (Haushofer et al., 2011). Thus questions remain about whether and how adversity may affect different stress systems.

In contrast, there is a clear association between poverty and early behavior problems. In a meta-analysis, Qi and Kaiser (2003) found that nearly 30% of children from low-SES backgrounds exhibited behavior problems in preschool, compared to 5% in the general population. Qi and Kaiser argued that multiple risk factors for behavior problems among children from low-income backgrounds might be due to the experience of sustained stress. Living in poverty may alter the development of stress response systems, which contributes to the development of behavior problems.

There is also evidence that physiological stress measures are linked to behavior problems. For example, low baseline cortisol is associated with higher externalizing symptoms in children concurrently (Granger et al., 1994; Shirtcliff et al., 2005; Tout et al., 1998; van Goozen et al., 2000) and with increases in externalizing symptoms longitudinally (McBurnett et al., 2000). Findings are less clear concerning the relation of cortisol to internalizing symptoms, though most studies suggest that high levels of cortisol predict greater likelihood of internalizing symptoms (Granger et al., 1994; Gunnar et al., 1997; Hart et al., 1995; Kagan et al., 1987; Schmidt et al., 1997). To date, only one study has investigated the relationship between sAA and problem behaviors in a longitudinal sample, demonstrating that higher externalizing behavior was predicted for children with either higher or lower levels of sAA than average across age in middle school (Keller and El-Sheikh, 2009).

In sum, previous research has demonstrated links between poverty and physiological measures (cortisol and sAA) of stress and between stress and behavior problems. However, few studies have examined the possible associations among poverty, physiological stress responses, and behavior problems, and no previous study has considered these associations over time. Theory suggests that early adversity may alter baseline sAA and cortisol activity, which in turn may influence the ontogeny of behavior problems, perhaps by impacting the developing brain (Johnson et al., 2013; McEwen, 2008). Whether low SES predicts behavior problems independent of sAA and cortisol or whether risk influences later behavior through a modified physiological reaction to stress remains an important and open question.

3. The current study

This study examines the developmental course of stress in early life by assessing three hypotheses. First, we expected that baseline levels of sAA would increase from 12 to 36 months (Davis and Granger, 2009; O'Donnell and Miller, 1980) while levels of cortisol would decrease over this same period (Gunnar et al., 1996; Watamura et al., 2004) as the stress response system matures. Second, we hypothesized that early poverty levels in children's families would differentiate patterns of change in both sAA and cortisol, and that