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The influence of emotion regulation, level of shyness, and habituation on the neuroendocrine response of three-year-old children

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Summary The current study investigated the temperamental dispositions of 53 three-year-old children (27 males, 26 females) and their behavioral and physiological responses to a stranger approach situation. Results indicated that elevations in cortisol were predicted by the child's level of shyness (with both shy and bold children showing elevations), better emotion regulation, and attendance at daycare which was believed to measure habituation to interactions with unknown adults in a playroom setting. In addition, the majority of children, both shy and bold, had cortisol levels that had begun to recover by fifteen minutes after the initial assessment. This suggests that the major concern for inhibited children is not weak regulation, but rather more frequent activation of the HPA system in response to novelty and a perceptual framework that expects fear.

With the advent of procedures to assay hormones in saliva, human research on one part of the physiological stress response, the hypothalamic-pituitary-adrenocortical (HPA) system, has flourished. Of particular interest have been findings that link temperamental differences in stress reactivity to health and behavior problems (e.g., Donzella et al., 2000). The aspect of temperament that has been most often associated with high levels of physiological reactivity is behavioral inhibition (e.g., Higley and Suomi, 1989; Gunnar, 1994; Kagan et al., 1987). It has been hypothesized that inhibited children have a lower activation threshold in the limbic areas of the brain, especially the amygdala. One of the stress-sensitive systems in which the amygdala is involved, at least in part, is the HPA system, the end product of which in humans is cortisol (Kagan et al., 1987, 1988; Gunnar, 1994; Gunnar et al., 1997).

Under acute circumstances, an elevation in cortisol allows the body to respond to challenging conditions by mobilizing energy resources and affecting memory, learning, and emotions in ways that help the organism manage the stressful situation. Cortisol also plays a regulatory role in other stress systems including the catecholamine systems, the endogenous opiate system, and the immune system. To accomplish these tasks, cortisol

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must divert resources from long-term functions like growth, digestion, and reproduction. Because there are few adverse effects as long as the system is turned off quickly and many benefits, small to moderate increases in cortisol are adaptive (e.g., Gunnar, 1991, 1992; Sapolsky, 2000). In fact, organisms deprived of cortisol are incapable of dealing with even normal daily physical and emotional challenges and thus can only survive in protected environments (Gunnar, 1992).

Chronic activation of HPA functioning, on the other hand, has been found to be related to problems with psychopathology in later life such as depression and anxiety, cognitive impairment (especially hippocampal damage), inhibited growth, drug and alcohol abuse, steroid disability, hypertension, immunodeficiency, and reproductive suppression (e.g., Sapolsky, 1990, 1996, 2000; Flinn, 1999; McEwen et al., 1992; Rutter, 1991; Gunnar and Donzella, 2002; Sullivan and Gratton, 2002; Majewska, 2002; Goeders, 2002; Gianoulakis, 1998; Cole et al., 1994; Carlson and Earls, 1997). In addition, stressful life events have been linked to infectious disease. For example, children in Bwa Mawego have almost twice the risk of illness for several days following naturally occurring high stress events (Flinn, 1999).

Cortisol, then, can be seen as a coping hormone that helps us to recruit resources—with successful recruitment related to strong regulation as evidenced by fast returns to baseline after the stressor (e.g., Stansbury, 1999; Davis et al., 1999; Gunnar, 1991, 1992; Sapolsky, 2000). However, it is a coping hormone whose persistent activation carries a heavy physiological cost. It is this biologic cost that has been the concern for inhibited children. One of the most powerful psychological triggers of the HPA system is uncertainty (Gunnar et al., 1989; Levine and Wiener, 1988), and uncertainty is believed to be a persistent problem for inhibited children who are often tentative as they face unfamiliar people, situations, or contexts (e.g., Kagan, 1999; Kagan et al., 1988). In fact, Schmidt and colleagues (Schmidt et al., 1997) hypothesize that high levels of cortisol in behaviorally inhibited children may increase CRH (corticotrophin-releasing hormone) in the central nucleus of the amygdala, exacerbating fearfulness, and that these higher levels of cortisol may predispose them to develop a perceptual framework to expect fear. This has been clearly shown in nonhuman research with highly reactive rhesus who interpret many situations as threatening. For example, when they are placed in novel environments or with new peers these monkeys immediately withdraw and begin to pump out glucocorticoids (Suomi, 1997; Higley and Suomi, 1989; Sapolsky, 1990).

Inhibited individuals, of course, are not the only ones to show cortisol reactivity. Research is now suggesting that the other end of the socially reactive spectrum, boldness or surgency, is also associated with increased cortisol levels. A study done by Tennes and Kreye (1985) that found higher basal cortisol levels in more outgoing second graders than in the inhibited ones provided an early hint of what later research has confirmed. Several studies have now reported a relationship between boldness and increased cortisol levels in response to group formation tasks in the lab and at the beginning of the school year for preschool and elementary students (e.g., Legendre and Trudel, 1994; Gunnar et al., 1997; Granger et al., 1994; Davis et al., 1999)—findings that have been extended to include greater cortisol reactivity by bold children in social activities (Flinn, 1999) and competitive games (Donzella et al., 2000). These results fit nicely with research on adults in which dominant men in army boot camp showed higher cortisol elevations in response to speech and running tasks than their less dominant cohorts (Hellhammer et al., 1997), and studies in the nonhuman literature which have found cortisol elevations for dominant individuals during group formation in response to various physical and psychological stressors (e.g., Manogue et al., 1975 who studied squirrel monkeys).

Of course, children differ not only on the reactivity dimension of temperament (i.e., the threshold and intensity of emotional experience), but also in the regulation of these emotions (i.e., the control or modulation of this reactivity). It is these two primary dimensions of temperament that interact to become behavioral patterns that can create different developmental trajectories for the child's personality and life (e.g., Rubin et al., 1995; Rothbart, 1989; Rothbart et al., 1992). For example, Rubin and associates found that low social interaction children who were poor regulators (highly and negatively emotional and hard to soothe) displayed more wary and anxious behavior in free play than average children or children low in social interaction who were good regulators. Similarly, high interaction children who were poor regulators displayed more externalizing problems than high interaction children who were good regulators or average children. Fabes and colleagues (Fabes et al., 1999) found that social appropriateness was also predicted by regulation, but only if the child was high in negative emotionality. If the child was not prone to intense emotions, regulation appeared to be less essential