Available online at www.sciencedirect.com
ScienceDirect
Infant Behavior & Development 31 (2008) 92–106
Infant Behavior & Development

Cortisol reactivity, maternal sensitivity, and learning in 3-month-old infants

Laura A. Thompson *, Wenda R. Trevathan

Psychology and Sociology/Anthropology Departments, New Mexico State University, United States

Received 31 October 2006; received in revised form 16 April 2007; accepted 3 July 2007

Abstract

This study investigated the effects of adrenocortical functioning on infant learning during an emotionally challenging event (brief separation from mother). We also explored possible relationships between maternal sensitivity and both infant and maternal cortisol reactivity during the learning/maternal separation episode. Sixty-three 3-month-olds and their mothers were videotaped for a 10 min normal interaction period, and mother–infant behavioral synchrony was measured using Isabella and Belsky's [Isabella, R. A., & Belsky, J. (1991). Interactional synchrony and the origins of infant-mother attachment: A replication study. *Child Development*, *62*, 373–384] coding scheme. The percentage of synchronous behaviors served as a measure of maternal sensitivity. Learning and short-term memory involved relating the infant's mother's voice with a moving colored block in a preferential looking paradigm. Infants whose cortisol increased during the session showed no learning or memory, infants whose cortisol declined appeared to learn and remember the association, while infants whose cortisol did not change evidenced learning, but not memory for the voice/object correspondence. Sensitivity and cortisol reactivity were correlated for mothers, but not for infants. Infant and maternal cortisol values for the first sampling period were highly correlated, but their cortisol reactivity values were uncorrelated, supporting the notion that infants and mothers have coordinated adrenocortical functioning systems when physically together, but become uncoordinated during a separation/learning event.

Keywords: Cortisol; Cortisol reactivity; Infant learning; Behavioral synchrony

1. Introduction

Young infants are in possession of many cognitive abilities that aid them in acquiring an expressive vocabulary of 50 words by the time they are about 16 months old (Bates, Bretherton, & Snyder, 1988). For example, they have highly developed visual and auditory sensory systems (Aslin, 1987) for encoding the auditory and visual components of objects or events that are named by their caregivers, and an attention system that is particularly responsive to human speech. Even newborns are differentially responsive to listening to their mothers' voices, compared to other female voices (DeCasper & Fifer, 1980), and by 2 months of age, can discriminate sentences differing by a single phoneme (Mandel, Jusczyk, & Kemler Nelson, 1994). Another prelinguistic ability needed to learn first words is

* Corresponding author at: Department of Psychology, MSC 3452/Box 30001, New Mexico State University, Las Cruces, NM 88003, United States. Tel.: +1 505 646 4024; fax: +1 505 646 6212.
E-mail address: thompson@nmsu.edu (L.A. Thompson).

0163-6383/$ – see front matter © 2007 Elsevier Inc. All rights reserved.
doi:10.1016/j.infbeh.2007.07.007

visual-auditory integration. During stimulus encoding, very young infants can coordinate visual objects with sounds (Spelke, 1979) and faces and voices (Walker, 1982). Finally, evidence for rapid word learning in 13-month-old infants can be found in recognition measures (e.g., Woodward, Markman, & Fitzsimmons, 1994). Long-term recognition of lengthy speech passages spoken by infants' mothers has even been demonstrated in 1- to 2-month-old infants (Spence, 1995).

Importantly, in studies such as these, after removing data from infants that were fussy during the experimental event, who fell asleep, or who showed biases in their responses to a region of the stimulus field, a final data set remains that is comprised of averaged data demonstrating the ability in the group at large; however, contained in this averaged set are data for infants who clearly possess the cognitive ability under question, as well as infants that do not. Ascertaining the nature of individual differences in cognitive processing is a central focus of many child developmental researchers (e.g., Siegler, 1978; Thompson, 1994). However, relatively little is known about the sources of individual variability potentially affecting infant learning.

One widely varying factor is infants' social-interactive environments. For example, infants' primary caregivers differ in how often they speak to their infants, in the prosodic variation of their speech, and in terms of the contingent nature of their language input. Nine- and 13-month-old infants whose mothers responded contingently to their vocalizations and play activities outperformed infants of less responsive mothers on several indices of language development, including timing in the onset of their first words and in combinatorial speech productions (Tamis-LeMonda, Bornstein, & Baumwell, 2001). Our primary interest is in furthering knowledge about the psychophysiological parameters affecting infant learning in the experimental context. That is, what differences inherent in infants, such as temperament and psychophysiological responding, contribute to differences amongst infants in their ability to attend to, learn, and remember speech/visual representations during a novel learning event?

One commonly studied psychophysiological measure is cortisol, an adrenal steroid hormone, which is secreted in response to physical and emotional stress and is also associated with high states of arousal. When the brain perceives a stress, corticotropin-releasing hormone is released from the hypothalamus, which then stimulates the pituitary gland to release adrenocorticotropic hormone, which, in turn, stimulates the release of cortisol from the adrenals (Sapolsky, 1992). Research on human adult populations shows that, up to a point, cortisol elevation is adaptive, but if the response is prolonged or severe, there appear to be negative effects on health, behavior, and learning and memory processes (e.g., Flinn & England, 2003). Maternal trauma experienced during pregnancy has even been shown to affect infant adrenocortical functioning *in utero* (Yehuda et al., 2005).

In most infant cortisol studies, the objective has been to understand how situational, emotional, and/or temperamental factors are associated with different patterns of adrenocortical functioning. As an example of situational variables, infant cortisol has been found to be higher at home than when tested at the same time of day in the laboratory following a car ride (Gunnar, Mangelsdorf, Larson, & Hertsgaard, 1989b), and is higher in the afternoon for preschoolers in poorer quality child care settings than in higher quality settings (Dettling, Parker, Lane, Sebanc, & Gunnar, 2000). Regarding behavioral emotional reactions, Lewis and Ramsay (2005) recently reported a study relating anger and sadness to cortisol response in 4- and 6-month-old infants. For both age groups, a goal blockage paradigm was used to activate the emotional response system. Four-month-old infants learned a contingency between an arm movement they initiated and a pleasant event, and subsequently learned that their behavior no longer reinstated the event. The researchers employed a still-face paradigm (Tronick, 2003) to test the 6-month-old infants, in which mother displayed a still face instead of a communicative response to her infant. Infants' facial and vocal affective displays were coded to determine the degree to which they felt anger, sadness, joy, and other emotions. Results showed that in both age groups, greater incidence of infants' expression of sadness was related to increasing cortisol response, but anger was not.

In some infant cortisol studies, a specific event occurred, and the adrenocortical response to the stressor was assessed and compared to a subsequent session. Any difference in the pattern of cortisol responding across sessions implied that infants remembered something about the original event. For example, across two sessions separated by 24 h, healthy newborn infants exhibited significantly reduced cortisol response to physical exam, and significantly greater cortisol response to heelstick (Gunnar, Connors, & Isensee, 1989a; Gunnar, Hertsgaard, Larson, & Rigatuso, 1992a). Cortisol levels also decreased in 6.5- to 13-month-old infants during two mother–infant swim classes (Hertsgaard, Gunnar, Larson, Brodersen, & Lehman, 1992), which was interpreted as an example of a novel event producing positive emotions, being remembered as pleasant, resulting in decreased cortisol levels over time (Gunnar & Donzella, 2002). However, in these studies, no measurements of infant cognitive abilities were reported.