

“Down Will Come Baby”: Prenatal Stress, Primitive Defenses and Gestational Dysregulation

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ABSTRACT. Knowledge of maternal stress and its direct influence on the developing embryo and fetus (prenate) can influence psychotherapeutic treatment decisions, especially when treating patients who are severely traumatized and dissociative. Not only may maternal stress alter prenatate neurobiological attachment and stress systems in the limbic-hypothalamus-pituitary-adrenal axis (LHPA) and limbic-autonomic nervous system (L-ANS), but it may also shape the development of prenatate ‘fixed action patterns’ built from primitive defensive reflex activation. As a result, the offspring’s defensive, mating and caregiving behavior may all be biased towards survival in a threatening world and may be more readily transmitted to subsequent generations. This theoretical article provides a prenatal relational model that outlines experience-dependent prenatate development that is contingent on and concordant with maternal regulation and dysregulation. Not only anxiety, depression and anger, but also posttraumatic stress and dissociation in the mother, may affect the neurobiology of the prenatate. doi:10.1300/J229v08n03_05 [Article copies available for a fee from The Haworth Document Delivery Service: 1-800-HAWORTH. E-mail address: <docdelivery@haworthpress.com> Website: <<http://www.HaworthPress.com>> © 2007 by The Haworth Press, Inc. All rights reserved.]

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The field of research in trauma and dissociation has primarily focused on children, adolescents and adults. However, studies in attachment have moved findings back to infancy, in particular, 12 to 18 month-old babies (Lyons-Ruth, 2002; Main & Solomon, 1990; Ogawa, Sroufe, Weinfield, Carlson & Egeland, 1997). Further, work by theoretical researchers, such as Allan Schore, explore infant neurobiological development and the deleterious effects of relational trauma during the first few years of postnatal life (Schore, 2001b, 2002). Even earlier in development, traumatology research in Neonatal Intensive Care Units (NICUs) has revealed behavioral and physiological symptoms of trauma in premature infants who struggle to survive in the extrauterine world of hospital wards (Als et al., 2004; Maroney, 2003; Portales et al., 1997; Suess et al., 2000). Moving back to the earliest gestational period of development, animal and human studies provide rich data indicating that during pregnancy maternal psychological stress, including dysphoric mood, profoundly alters prenatate (embryo and fetus) physiological systems, especially the behavioral and biological stress systems (Cratty, Ward, Johnson, Azzaro & Birkel, 1995; Field, Diego & Hernandez-Reif, 2006; Kofman, 2002; Morgane, Mokler & Galler, 2002). Like traumatized NICU preemies, stressed prenates exhibit similar behavioral and physiological dysregulation (Arduini, Rizzo & Romanini, 1995; Smotherman & Robinson, 1995b). Since these stress responses are similar to the physiological responses evidenced in traumatized patients, the question arises as to whether prenates' experience their own form of trauma, yet without the cognitive capacity to interpret events as traumatic. In this article, to help reduce confusion, the term stress will be used to differentiate cognitively comprehended trauma from somatic/physiological stress responses. The term 'prenatal' will be used to include mother and offspring; whereas, the term prenatate will only refer to the offspring, since prenatate incorporates both embryonic and fetal stages of development.

This theoretical article provides a prenatal relational model. First, this article presents evidence that prenates' stress responses occur and are contingent on maternal stress. Prenates do display a non-verbal vocabulary that portrays their distress. Since prenatate motor behavior reveals functioning within the central (CNS) and autonomic nervous system (ANS) it serves as a reliable indicator of subcortical and

sensorimotor cortical development (Amiel-Tison et al., 2004; Cheng, Zhou, Qu, Ashwell & Paxinos, 2004; DiPietro, Bornstein et al., 2002). Second, this article posits that prenatal neurobiological stress behavior may possibly be the earliest sign of traumatic and dissociative symptomatology, and that postnatally, if the caregiving environment remains stressful for the infant, especially if stress is embedded in the infant-caregiver interactions, the infant may maintain these prenatal stress responses.

Stress states in the prenatal and neonate can be recognized by elevated heart rate, greater activity levels (gross body, single and multiple limb actions), greater physiological reactivity, and lower habituation yet higher reflex activation (Field et al. 2006). The prenatal and neonate may show pronounced stilling, mistimed diffuse movement, overt grimacing and indeterminate sleep-wake states. Although these behavioral states may reflect general neurological or ANS dysregulation, if the neonate only displays stress behaviors in response to a primary caregiver, signs of disorganized attachment may manifest (Hesse & Main, 2006; Main & Solomon, 1990; Pipp-Siegel, Siegel & Dean, 1999). This article outlines the hypothesis that infant disorganized behavior may have roots in the early forming prenatal primitive defensive reflexes, reflexes that are activated in response to aversive or noxious stimuli. If the mother's stress compromises the neurobiological development of her prenatal, then defensive reflexive 'fixed action patterns,' which are deeply interconnected with the developing limbic-autonomic nervous system (L-ANS) and limbic-hypothalamic-pituitary-adrenal axis (LHPA) (Goddard, 2005), may become the template for future 'fixed action patterns' (Linas, 2001). And these complex motor-physiological-emotional patterns have the potential to bias subsequent development.

Throughout this article, the principles of experience-dependent maturation are applied. It is posited that second generation effects of maternal unresolved states of mind about trauma and/or loss (Hesse, Main, Abrams & Rifkin, 2003) may not only be transmitted during infant-caregiver interactions, but may also be physiologically transmitted from the pregnant mother to the prenatal (Amiel-Tison et al., 2004; Huizink, Mulder & Buitelaar, 2004). In addition, since emotional responsivity and motor behavior are intrinsically integrated in early development, strong focus on movement behavior will be interspersed throughout this discussion. Only during the last quarter of the first year and into the second year of postnatal life, when the lateral and medial orbital prefrontal cortex differentiates, does movement and emotion begin to separate into more discrete circuitry (Northoff et al., 2002; Schore, 1994; Schore,

2003), a time period when movement gradually comes under more voluntary motor cortex control. As stated, prenatal movement cannot be isolated from L-ANS and limbic-central nervous system (L-CNS) processes (DiPietro, Bornstein et al., 2002; James & Pillai, 1995). In fact movement assessment in early infancy is a robust predictor for neuro-motor, emotional and attentional problems in late childhood (Friedman, Watamura & Robertson, 2005; Groen, de Blecourt, Postema & Hadders-Algra, 2005; Patin, Lordi & Caston, 2004). This article synthesizes neurobiological findings on L-ANS and L-CNS development, including the maturation of primitive defensive 'fixed action patterns.' All are integrated into a prenatal experience-dependent relational model.

It is hoped that increased knowledge of prenatal stress will inform psychotherapeutic treatment protocols, especially when treating severely traumatized and dissociative patients who may themselves have suffered early prenatal stress. Further, when these patients become pregnant, appropriate treatment for the mother may benefit the offspring. When clinicians provide therapeutic intervention to a pregnant woman the prenatal may also be affected (Field, 2001; Ponirakis, Susman & Stifer, 1998). One overarching goal of this article is to help clinicians understand the potential deleterious effects of prenatal stress.

PRENATE MATURATION- A DYADIC RELATIONSHIP

Prenatal development emerges as a series of gene-directed, and experience-dependent abrupt changes that occur within critical periods of maturation. For example, one of the most dramatic changes occurs in the first moment of conception. Rather than the usual mitotic process of cell division, conception is initiated by meiosis—literally two separate cells, the largest cell in our species, the egg, and the smallest cell, the sperm, unite to form a single new cell (Larsen, 2001). This 'zygote' cell carries the blueprint for an individual that has never existed before and will never exist again. Extraordinary changes proliferate during intra-uterine development as the zygote becomes a gamete, then a blastocyst, an embryo, a fetus and finally a neonate (Dye, 2000).

Like the growing acceptance that optimal early infant and childhood development is contingent upon regulated age-appropriate experience-dependent interactions, especially with attachment figures (Schorer, 2001a), prenatal development is equally dependent on the dyadic interactions with the mother. The placenta, a region where neurochemicals

are exchanged between mother and offspring, is a shared region where the mother's and prenat's blood supply interact in an ever changing amplifying or dampening process, as is evidenced by maternal levels of corticotrophin-releasing hormone (CRH) being enhanced in the placenta by fetal CRH (Dye, 2000; T. Fujioka, A. Fujioka, Endoh, Sakata, Furukawa & Nakamura, 2003; Glynn, Wadhwa & Sandman, 2000). Mother and prenat also interact through direct sensorimotor stimuli. Most mothers recognize fetal movement and begin to identify their offspring's sleep-wake cycles while fetuses respond to, and eventually habituate to, extrauterine sounds, as well as intrauterine sensations of maternal movement behavior and neurochemical signals produced by her diet and stress (Leader, 1995; Sandman, Wadhwa, Chicz-DeMet, Porto & Garite, 1999; Thomson, 2004; Wadhwa et al., 2002). These ongoing and often direct sequencing interactions ultimately familiarize and prepare the prenat for future entrance into the socio-economic and cultural world of the mother (Nathanielsz, 2001; Salm et al., 2004). Newborns are prepared to reflexively 'grasp' onto caregivers for survival and immediately recognize and show preference for tastes, smells and sounds of their mothers just as mothers can differentiate and respond to the unique smells and sounds of their newborn (Beebe & Lachmann, 2002; Bornstein & Lamb, 2005; Bornstein & Patricia, 2000; Goddard, 2005).

According to DiPietro, Costigan and Pressman (2002) "The post-conceptual age at which birth normally occurs does not represent a significant transition in neurobehavioral development" (p. 1). In other words, birth marks a change for respiratory functioning from fluid to oxygen, a more aerobic environment for brain development and increasingly more complex interpersonal sensory-affective engagements (Schoe, 2001b). But it is only one developmental step amongst many that have already taken place. For the newborn, these seemingly new extrauterine experiences are more familiar than once thought. Preparation for extrauterine life is operational from embryonic through fetal development such as; swallowing amniotic fluid to stimulate gastro-intestinal systems (Eliot, 1999), hiccupping to activate diaphragmatic breathing (Stark & Myers, 1995), increasing cortisol levels, especially during the last trimester, to enhance lung development (Glynn et al., 2000), increasing oxygenated hemoglobin in the blood stream to compensate for the anaerobic uterine environment (Dye, 2000), repeatedly engaging reflexive motor behaviors in preparation for grasping, sucking, balancing, blinking, walking and defensively responding to external threat (Goddard, 2005) and processing, learning and habituating to

increasingly complex sensorimotor stimuli (Sandman et al., 1999; Smotherman & Robinson, 1995a).

CONCORDANT PRENATE AND MATERNAL STRESS

Further, DiPietro, Costigan and Pressman (2002) state “An underlying assumption for both fetal and infant neurobehavioral assessment is that stable individual differences emerge in development, and that early functioning predicts generalized or specific aspects of subsequent development” (p. 2). What occurs during gestation determines the establishment of stable or unstable regulatory systems, especially within the structural-functional formations of the LHPA axis (Weinstock, 1997), the ANS (Coalson & Tomasek, 1992; Ng, 2000; Schweiger et al., 2004), sensorimotor, vestibular and proprioception systems (DiPietro, Bornstein et al., 2002) and the functional connectivity between limbic forebrain and midbrain/diencephalon regions (Shumake, Conejo-Jimenez, Gonzalez-Pardo & Gonzalez-Lima, 2004).

Although Allan N. Schore does not write about prenatal development, he makes an eloquent claim for the importance of the earlier forming lateralized socio-affective experience-dependent right hemisphere and the role it plays in attachment formation and psychopathology (Schore, 2001a, 2002; Thayer & Lane, 2000). Optimal formation of the right lateralized socio-emotional brain is directly shaped by the right-brain to right-brain interactions between caregiver and infant (Schore, 2001a), and it is these same experience-dependent neurobiological regulatory interactions, although through different interactive modalities, that shape the earlier period of prenatal gestation. The right lateralized regions of the sub-cortical and meso-limbic areas are rapidly maturing in the prenatal. Since regions of accelerated growth (critical periods) are vulnerable to excessive cell death, the entire gestational period, marked by multiple and overlapping neurobiological critical periods, can be considered a time of great prenatal vulnerability (Schore, 1994; Tucker, 2001).

At every stage of development genes guide the timing but environmental influences modify the genotypic formation (direct genetic inheritance) into the unique phenotype (adaptive environmental influence that shapes gene expression) of the maturing offspring (Thomson, 2004; Thorogood, 1997). This gene-environment interaction specifically tailors the unborn for the world it is to enter. For example, during the first trimester the embryo is permanently compromised or destroyed

by maternal exposure to teratogens, such as the devastating deformities caused by exposure to lead, alcohol or the rubella virus (Larsen, 2001; O’Rahilly & Muller, 1999a; Pinel, 2000). It is known that maternal nutrition powerfully shapes the development of the prenat, with direct implications for future occurrences of obesity, diabetes, and cardio-pulmonary disease, along with increases in morbidity and mortality rates (Barker & Lackland, 2003; Morgane et al., 2002; Nathanielsz, 1999, 2001). And excess chronic maternal stress (Anisman, Zaharia, Meaney & Merali, 1998; Fujioka et al., 2003; Hayashi et al., 1998), as well as mood disorders (Field et al., 2004; Lundy et al., 1999; Monk, 2001), and the fluctuating dysregulated states of posttraumatic stress disorder (PTSD) and dissociative disorders, can also have long-term effects on the neuronal development and behavior of the offspring (Huizink et al., 2004; Weinstock, 2001). Cumulative research indicates that the developing CNS, including regions designated to respond to stress, are most vulnerable to seemingly minor insults. Further, excess stress during critical periods may have long-lasting effects (de Graaf-Peters & Haddrs-Algra, 2006; O’Rahilly & Muller, 1999a; Salm et al., 2004).

According to traditional folk wisdom, a happy baby comes from a happy mother (Shonkoff & Phillips, 2000). DiPietro, Hilton et al. (2002) cite the 1934 work of Sontag and Wallace; “We have frequently heard the statement made by expectant mothers that any sudden feeling of fear or of anger produces an almost immediate and marked increase in the number and violence of the fetal movements” (p. 659). An awareness of maternal emotional factors influencing pregnancy has been revealed since Hippocratic writings (Huizink, DeMedina, Mulder, Visser & Buitelaar, 2002). Although a wealth of research supports the harmful effects of maternal stress during gestation, it should be noted that some research findings claim that mild prenatal stress can actually enhance the offspring’s learning performance, reduce emotionality and accelerate respiratory development, especially when it occurs during the last trimester, a stage of development when fetal regulatory vagal tone increases (Diego et al., 2002; Fujioka et al., 2001).

Prenatal development is a dyadic relationship between mother and offspring, and it is also a relationship between mother and her immediate surroundings. At one time, family and community shared in the responsibility of pregnancy; however, in western societies this communal support has slowly diminished (Shonkoff & Phillips, 2000). Pregnant women are expected to maintain the stressful demands of modern life, and for women living in lower socioeconomic environments, the daily stress of financial constraint and poor nutrition places even greater

neuropsychobiological strain on the developing offspring (Kofman, 2002). Even worse, when pregnant mothers experience ongoing dysregulation caused by physical and emotional trauma such as during domestic violence, prenatal development may be compromised.

Not only the external world of the mother is a stressor during pregnancy, but unresolved histories of early relational trauma and/or loss, often remaining actively dysregulating in the intrapsychic mind of many psychologically disordered patients, may become a powerful source for prenatal stress. These unresolved states of mind are currently considered factors in the second generation effect of future disorganized attachment relationships between caregiver and infant (Hesse & Main, 2006; Hesse et al., 2003; Hughes, Turton, Hopper, McGauley & Fonagy, 2001; van Ijzendoorn, 1995). Research findings, such as infants born subsequent to a mother's earlier stillbirth experience are more disorganized (Hughes et al., 2001), suggest that a mother's unresolved state of mind as observed in the Adult Attachment Interview (Main, Goldwyn & Hesse, 2002; van Ijzendoorn, 1995) may have correlates to biological stress states in the mother that are transmitted to the prenatal/neonate (Cameron et al., 2005; Fleming et al., 2002; Schechter, Kammerer, Grienenberger & Amat, 2003). These unresolved states of mind may manifest in the mother as elevated corticotrophin-releasing-hormone (CRH) and either elevated or suppressed cortisol levels, neurochemicals associated with activation of the LHPA (Jones et al., 2006; van der Kolk, 1994; Yehuda et al., 2005). And stressed maternal LHPA responses are not only transmitted to the offspring but are often amplified in prenatal LHPA systems (Field et al., 2006; Glynn et al., 2000). In a study on mothers stressed from 9/11, Yehuda et al. (2005) found "lower cortisol levels in relation to maternal PTSD were most apparent in babies born to mothers who were in their third trimester on 9/11. . . . The data suggest that effects of maternal PTSD on cortisol can be observed very early in the life of the offspring and underscore the relevance of in utero effects as contributors to putative biological risk factor for PTSD" (p. 4117).

These findings support the theory that PTSD and dissociative disordered patients, who are typically unable to effectively regulate intense emotional states, are more likely to transmit their dysregulated states to their offspring (Fleming et al., 2002; Hesse & Main, 2006; Lyons-Ruth, 2002). Psychopathologically disordered patients, already in extreme distress, often become even more dysregulated during the rapid hormonal fluctuations of pregnancy. If ambivalent feelings about pregnancy are included, prenatal development may be profoundly

challenged. Since chronic prenatal stress responses persist postnatally (DiPietro et al., 2003; DiPietro, Hilton et al., 2002; Fujioka et al., 1999; Salm et al. 2004; Weinstock, 1997), these regulatory stress systems may influence the offspring's burgeoning sense of self (Amiel-Tison et al., 2004; Patin et al., 2005), especially since the offspring is building a physiological foundation of neuroendocrine, immune/inflammatory and cardio-vascular processes essential for stable self-regulation. Although these systems can be modified postnatally by either impoverished or enriched caregiving, they are nonetheless established during prenatal development (Amiel-Tison et al., 2004; Card, Levitt, Gluhovsky & Rinaman, 2005; de Weerth, van Hees & Buitelaar, 2003; Degangi, Breinbauer, Doussard-Roosevelt, Porges & Greenspan, 2000; McEwen, 2003a; Porges, 2004; Schmidt et al., 2003). Ultimately, the nature, duration and timing of the occurrences of stress during gestation all influence the prenatal's formation of self-regulatory processes (Wadhwa et al., 2002), and possibly the formation of traits and temperament (Gutteling et al., 2005; Perry, Pollard, Blakley, Baker & Vigilante, 1995).

REFLEXES AND PRENATAL DEVELOPMENT

Prenatal reflex activation is critical to support experience-dependent central nervous system maturation, and like all optimal development, activation operates on a continuum. Too much or too little reflex activation leads to unstable state regulation and compromised CNS and ANS development (Taylor, Houghton & Chapman, 2004). The natural course of development has a hierarchical progression from rudimentary to more complex behaviors (de Graaf-Peters & Hadders-Alga, 2006; O'Rahilly & Muller, 1999b). During prenatal development, all reflexive behaviors emerge and then are 'practiced' and strengthened in preparation for life outside the womb. These waxing and waning movements are reliable indicators of the gestational maturation of the CNS and ANS (Cheng et al., 2004; DiPietro, Hodgson, Costigan, Sterling & Johnson, 1996; Eaton, McKeen & Campbell, 2001; Patin et al., 2004; Schouenborg, 2002).

Since primitive motor reflexes operate throughout most of prenatal development, it may be that they are the primary ingredient of all phylogenetic 'fixed action patterns.' According to Rodolfo Llinas (2001), "These motor patterns are called 'fixed' because they are quite stereotyped and relatively unchanging not only in the individual, but in all in-

dividuals within the species” (p.133). Sets of ‘fixed action patterns’ become more complex with the elaboration provided by emotional limbic structures and the two branches of the ANS. With each repetition of motor reflexes, an experiential ‘self’ is constructed from neuronal networks that integrate these stereotyped reflexive responses (Llinas, 2001). It is well documented that repetition of all motor behavior facilitates a transfer to procedural implicit memory conducted at the level of the basal ganglia and cerebellum (Ivry & Spencer, 2004; Schweighofer, Doyer & Kuroda, 2004; Shumway-Cook & Woollacott, 2001). Once operating as learned motor behavior entire sets of organized physiological and psychological responses can easily be activated. As development progresses postnatally some of these reflexive ‘fixed action patterns’ differentiate into voluntary somatic motor control, semi-voluntary somatic-autonomic motor behavior and fully involuntary autonomic activity (Bornstein & Lamb, 2005). Although developmental maturation ensures the emergence of complex motor behavior, ‘fixed action pattern’ behaviors persist throughout the lifespan. They are characterized as a consistent progression, where a single stimulus elicits a chain of events that proceeds in a predictable sequence, with some minor variations incorporated during the sequence (Wilson-Pauwels, Stewart & Akesson, 1997). Behaviors such as smiling during a pleasurable greeting, frowning with distress, hypertonic striated muscle activation when angry and grimacing with disgust are evident in all human behavior. Early in gestational development these ‘fixed action patterns’ incorporate a cascade of neuroendocrine and neurotransmitter chemicals that respond to the single stimulus. Generally this cascading response persists throughout our lifespan, unless we become neurologically impaired (Llinas, 2001).

Some of the many pre-nate reflexes that become the foundation for later forming complex motor behavior include; grasping (Palmar), powerfully linked to the essential need to grasp or ‘attach’ onto the caregiver; sucking, essential for feeding and soothing; postural righting reaction, supporting head lifting to ensure clear airways and stepping, preparing for ambulatory movement (Bornstein & Lamb, 2005; Goddard, 2005). The primitive defensive reflexes underpinning threat response behavior also emerge during pre-nate development. As brain development progresses, more hierarchically complex neuromotor control subsumes reflexive behavior but these behaviors do not disappear, rather they reside as foundational motor responses (Goddard, 2005; Malina, Bouchard & Bar-Or, 2004).

PRIMITIVE DEFENSIVE REFLEXES

The three primitive defensive reflexes, in their developmental order include the Withdrawal reflex, the Moro reflex and finally the Startle (Strauss) reflex. As the pre-nate and newborn develop, the first primitive defensive reflexes, operating in tandem with the dorsal vagal and sympathetic-adrenergic systems of the ANS (Beauchaine, 2001; Cheng et al., 2004; Kumar, Dereddy, Bhatia & Prakash, 2005; Ruggiero, Zhao, Awar & Sica, 2004), gradually come under the hierarchical regulation of the social engagement system of the ventral vagal system. The ventral vagal complex enables infants to cry for help and later communicate with socially and emotionally nuanced language skills (Goddard, 2005; Porges, 2004). However, the earlier primitive defensive reflexes can always re-emerge under traumatic conditions or as a result of neurological disorders. Further, it is posited that when defensive reflexes, along with their deep neural connections to the limbic amygdala/HPA and ANS (Goddard, 2005), are repeatedly activated during pre-nate development, they may likely never be fully suppressed or regulated by the ventral vagal complex.

Stressed pre-nates may spend nine months ‘training’ and ‘preparing’ for the demands of entering a hostile external world. They may arrive with a physiological and motor reflexive bias to threat. Like well-trained fighters, these offspring rapidly, efficiently and instinctively engage defensive reflexive behaviors. If their caregiving extrauterine world is not protective these defensive strategies may persist as they struggle to survive. Unfortunately, the ongoing trajectory away from stable regulatory balance of homeostasis to unstable stressed states create a compensatory response described by Bruce McEwen as allostatic loading that eventually leads to increased morbidity and mortality (McEwen, 2003a).

Withdrawal Reflex

The earliest defensive reflex, Withdrawal, emerges just five weeks post-fertilization when the embryo first shows motor responses to stimuli. The behavior is one of total body withdrawal, such as withdrawing from a loud noise or from a strong blow to the mother’s abdomen (DiPietro et al., 2003; Glynn et al., 2000; McDonald, 2004). The embryo shows behavioral signs of immobility, slowing of heart rate, drop in blood pressure and hypoxia—all physiological symptoms of extreme dysregulating ontological fear (Goddard, 2005; Smotherman & Robin-

son, 1995b). This reflex most likely operates in tandem with the dorsal vagal complex, which Stephen Porges' describes as the earliest defense system (Reed, Ohel, Rahav & Porges, 1999). The slower unmyelinated dorsal motor nucleus of the vagal tract of the parasympathetic nervous system forms during late embryological development (Larsen, 2001; O'Rahilly & Muller, 1999b), along with the modular organization of the somatosensory spinal withdrawal reflex (Schouenborg, 2002). Further, the Withdrawal reflex is often related to the diving reflex, which is thought to be a physiologically protective oxygen-conserving mechanism in all human infants and children (Goddard, 2005). Like the dorsal vagal system, a system that Porges implicates as extreme shut-down (Porges, 2001), this extreme Withdrawal reflex response may be associated with the hypo-aroused state often classified as cataplexy (Krahn, Lymp, Moore, Slocumb & Silber, 2005), catatonia (Moskowitz, 2004; Northoff et al., 2002), or the negative symptoms of somatoform and psychoform dissociation (Nijenhuis, van der Hart & Steele, 2002; Perry, 1999; Schore, 2001b).

Moro Reflex

The second emerging defensive reflex is the bi-phasic Moro. It matures in tandem with increased tactile awareness and greater activation from the later forming sympathetic branch of the ANS. The Moro reflex offers protection from over-engagement of the energy-depleting total body Withdrawal reflex. The Moro reflex develops in two stages and is marked by two separate motor patterns. The first stage emerges between 9-12 weeks post-fertilization and the second phase appears much later, around 32 weeks post-fertilization, a period when the parasympathetic nervous system, and in particular, the myelinated tract of the ventral vagal complex is actively regulating fetal responses to stress (Cheng et al., 2004; DiPietro et al., 1996). The Moro reflex is the earliest sympathetic-adrenergic fight or flight response, and may occasionally manifest in later life during situations of extreme danger. However, with normal maturation, it should be inhibited in its crude form around 2-4 months postnatally to be replaced by the adult Startle (Strauss) reflex (Goddard, 2005).

The first Moro stage is characterized by a sudden symmetrical movement of the arms upward, away from the body, legs move outwards, hands open, head extends backwards with a momentary freeze, and after birth a rapid intake of breath is incorporated. The second stage is marked by a return to midline with a gradual return of the arms across

the body into a clasp posture while the legs curl back in towards the chest, and postnatally, the breath is released. Both stages of the Moro reflex involve high sympathetic nervous system arousal including increased heart rate, immediate rise in blood pressure, rapid shallow breathing, flushing of the face and hypertonic musculature accompanied by limbic system responses that will manifest after birth as anger or distress. One or both motor patterns can be sensitized during prenatal development and will ultimately lead to different developmental trajectories. According to Sally Goddard (2005), if the first stage of the Moro reflex remains over-active, then the infant is at risk for muscular hypertonicity along with a pattern of breath holding that may persist well into childhood. The tight adductive behavior of the second Moro response also requires hypertonicity and rather than breath-holding the infant or child often displays excessive sighing. This overactive sympathetic-biased defensive reflex becomes toxic for the fetus, since catabolic energy-expending hyperactivation depletes metabolic amino acids, oxygen and neurotrophic growth factor levels essential for neurogenesis and synaptic density (Amiel-Tison et al., 2004; Kofman, 2002; Thomson, 2004). Gestational stress is often evidenced by fetal motor hyperactivity, and excessive activation of the Moro reflex may strongly correlate with delayed maturation of the nervous system involved in motor skills, particularly, alterations in the cerebellum (Patin et al., 2004), impairment in attentional and learning systems (Huizink et al., 2004; Taylor et al. 2004), increased responsivity to novelty with a decrease in habituation due to toxic levels of CRH to the developing hippocampal and parahippocampal regions (Sandman et al., 1999), and dysregulation in fetal heart rate variability and vagal tone causing respiratory and feeding disorders for the newborn (Degangi et al., 2000; Doussard-Roosevelt, McClenny & Porges, 2001; Portales et al., 1997; Suess et al., 2000). The cascading effects of over-stimulating Moro behavior may lead to imbalances in neural networks that bias the connectivity and complexity of prenatal brain structures and functions.

Startle (Strauss) Reflex

The third and final defensive reflex, the Startle reflex, develops around four months postnatally. The adult Startle reflex consists of a shrugging movement, followed by a turn of the head to check the source of disturbance (orienting response). Once the source has been identified the infant/adult can proceed with whatever it was doing (including sleeping) or can mobilize for a fight/flight response. The Startle reflex is

characterized as a slight flexion of the legs and trunk, a forward flexion of the head, followed by a rising and forward movement of the shoulders, a forward rising and inward turning of the arms, pronation of the forearms, closing of the hands, eyelid blinking, facial grimacing and contraction of the abdominal muscles. This response is much more economical than the extreme sympathetic driven Moro or dorsal vagal parasympathetic driven Withdrawal reflexes. The Startle reflex allows more balance in the respiratory and cardio-pulmonary systems and expends much less energy (Malina et al., 2004).

PRENATE LIFE AND STRESS BEHAVIOR FORMATION

Defensive reflex behavior is part of normal prenatal and postnatal development; however, over-activation of any or all of these defenses influences biological and psychological development. Regardless of age, these defensive ‘fixed action patterns,’ when persistently activated, impede normal activities such as reading, writing, walking and sleeping (Goddard, 2005). Further, it is hypothesized that defensive reflex strategies may be activated in disorganized infant attachment behavior. For example, the disorganized attachment criteria of infant freezing, stilling, slowing or limp movements while in the presence of the primary caregiver (Main & Solomon, 1990; Pipp-Siegel et al., 1999) may have their neurobiological roots in the Withdrawal defensive reflex. Incomplete, contradictory, or mistimed movements may originate from the sympathetically driven two-stage Moro reflex. Stereotypies and anomalous postures may result from alterations in the early forming vestibular system, a biological system that underpins spatial organization and regulatory balance (Goddard, 2005; Porges, 2004). Direct indices of apprehension regarding the attachment figure can be seen with gestures and body postures such as a hand moving to the mouth or forehead, the body contracting or hunching, highly vigilant postures or sudden confused wandering or crumbling behavior.

These distress signaling behaviors, although they may be markers for neurological impairment in neonate assessment (Friedman et al, 2005; Groen et al. 2005; Patin et al, 2004; Pipp-Siegel et al., 1999), are elements of pre-nate defensive ‘fixed action patterns.’

With advances in prenatal imaging, including 3-D and 4-D (fetal movement in three dimensions) imaging, direct reactions of fetal distress are observed, such as grimacing and writhing responses to sudden jolts or sounds on the mothers’ abdomen (McDonald, 2004). As early as

12 weeks post-fertilization, fetuses actively respond to aversive stimuli such as spitting out amniotic fluid that carries unpleasant tastes or covering their ears to block out painful ultrasonic waves (Eliot, 1999; Lecanuet, Fifer, Krasnegor & Smotherman, 1995). Despite current theory suggesting entrance into the external world is the first step in infant-caregiver attachment formation, prenatates have been interacting at levels of the sensorimotor-ANS throughout gestation. Mothers and prenatates, in fact, have concordant regulated and dysregulated physiological states (DiPietro, Costigan & Pressman, 2002). These shared states are transmitted through the placenta (Glynn et al. 2000) and through the ever maturing sensorimotor central nervous system of the offspring (Kofman, 2002).

Prenate behavior generated in response to maternal stress resembles the fluctuating dysregulated hyper- hypo-aroused symptoms of overwhelming stress (Smotherman & Robinson, 1995b), hence prenatates may experience a form of fear and helplessness, with the fear and helplessness measured by neuroendocrine and behavioral signs. Certainly stress to the prenatate compromises physiological and physical growth along with motor, emotional and attentional regulation (Field et al. 2006).

Further, future defensive and reproductive strategies actually emerge during the formation and maturation of the hypothalamic nuclei and the circuits that extend into the autonomic and neuroendocrine systems (Cameron et al., 2005; Shonkoff & Phillips, 2000). Developmentally, the earliest embryonic stage is the most vulnerable, with later stages showing fewer alterations. Maternal stress during the first trimester strongly influences prenatate motor, vagal and autonomic systems (when the Withdrawal and first stage Moro reflex form). More sensory awareness develops during the second trimester, which initiates an elaboration on motor and L-ANS activation (Cheng et al., 2004). During the third trimester, fetal sensorimotor systems come under greater control of the ANS, and with increased myelination, greater neuronal connections facilitate the stability of fetal movement and sleep-wake states. But with chronic maternal stress these systems remain unstable and poorly connected while defensive 'fixed action patterns' strengthen (DiPietro, Bornstein et al., 2002; DiPietro, Costigan & Pressman, 2002; DiPietro et al., 1996; Eaton, 2001; Patin, 2004). These defensive sensorimotor patterns activate a cascade of neurochemicals resulting in a physiological and behavioral stress system resembling traumatic stress symptomatology (van der Kolk, personal communication, February 22, 2006). With chronic activation during prenatate development,

they re-sculpt neurobiological circuits and systems. Some of the many alterations include changes to the following regions and systems:

1. at the ANS level, decreased vagal tone causes reduced prenatate heart rate variability and dysregulated sympathetic and/or dorsal vagal tone (DiPietro, Costigan & Gurewitsch, 2003; Porges, 2001),
2. alterations at every level in the L-HPA, as evidenced by excess secretions of CRH by the hypothalamus (Amiel-Tison et al., 2004; Fujioka et al., 2003; Glynn, 2000; Huizink et al., 2002), elevated or suppressed activation in cortisol production in the adrenal glands (Yehuda et al., 2005) and in adrenocorticotropin hormone (ACTH) production in the pituitary gland (Jones et al., 2006). Other hypothalamic changes include alterations in noradrenalin with increases in the basal level of the hypothalamus, but decreases in the medial preoptic and median eminence of the hypothalamus (Huizink et al., 2004),
3. decreased opioid receptors and dopamine levels and increased serotonin, norepinephrine and cholinergic synthesis that compromise the formation of the prenatate's regulatory systems (Amiel-Tison et al., 2004; Field, Diego et al., 2004; Lundy et al. 1999),
4. profound impairment in the essential functioning of the fore-brain-limbic inhibitory systems includes a decoupling of this system from the subcortical limbic midbrain-diencephalon regions (Shumake et al. 2004), and alterations in hippocampal processing caused by decreased levels of gamma-aminobutyric acid (GABA) (Amiel-Tison et al., 2004; Cameron et al., 2005; Huizink et al., 2004),
5. diminishment of inhibitory regulatory systems is compounded by the effects of long-lasting upregulation of CRH in the amygdala, leading to hyper-emotionality (Cratty et al., 1995; Bonne, Grillon, Vythilingam, Neumeister & Charney, 2004), and enduring alterations in the lateral amygdala, the major gateway into the amygdala where learned fear and hyper-sensitivity and hyper-responsivity is effectuated (Salm et al., 2004).

These changes bias the prenatate toward rapid mobilization of defensive strategies that remain dysregulated and unmodulated due to alterations in the inhibitory feedback neurochemical systems of cortisol, GABA, serotonin and opioids, and inadequate regulatory activation of the hippocampus.

These findings suggest that dysregulated physiological and motor responses are operational during prenatal defensive behavior. Repeated primitive defensive Moro and Withdrawal reflex activation seems to set in motion a bi-phasic fluctuation of increased frenetic excitation followed by severe and prolonged suppressed motor behavior. Persistent fluctuations throughout gestation seem to alter the normal developmental pattern of early waxing and third trimester waning movement behavior (DiPietro, Hilton et al., 2002; Kumar et al., 2005; Patin et al., 2004).

Reproductive patterns are also altered evidenced by shifting balances of oxytocin receptors in the ventromedial and preoptic nuclei of the hypothalamus (Cameron et al., 2005). In rats, these hypothalamic changes lead to delayed and compromised motor and cognitive development, as well as to the accelerated progression of early onset of puberty. Stressed offspring reproductively mature sooner and essential caregiving instincts orchestrated by oxytocin, opioids and dopamine are negatively compromised by the reshaping of the hypothalamic nuclei in the ventromedial region (Cameron et al., 2005). The need to reproduce quickly, to procreate with multiple partners and a lack of interest in caregiving seem to be driven by alterations in the formation of the hypothalamus during embryonic development (Huizink et al., 2002), although modifications in the hypothalamus may occur if early postnatal caregiving is attuned to the infant's developmental and emotional needs (Card et al., 2005). This is especially true when it involves the sensitive caregiving support provided by touch, vocal prosody, visual gaze and familiar smells—all modalities that stimulate secure attachment formation (Bowlby, 1988; Field, 2001; Schore, 2001a).

Ongoing maternal stress frequently results in premature parturition, small-for-gestational size, metabolic syndrome disorders and delayed central and ANS development (Glynn et al., 2000; Jones et al., 2006; Weinstock, 2001; Yehuda et al., 2005). Although severely compromising, these changes in the prenatal may facilitate survival of the species, since rapid responses to threat and accelerated sexual development support opportunities for the offspring to live long enough to procreate. These stress responses direct the offspring's subsequent motor, cognitive and emotional behavior. Withdrawal, anxiety, timidity and passivity, along with the seemingly contradictory behavior of aggression, high risk-taking and over-controlling responses are all predictable outcomes of chronic prenatal stress, especially when stress persists postnatally (Goddard, 2005; Kofman, 2002; Salm et al., 2004). During development, these extreme inhibitory and externalizing responses may become dominant behavioral patterns.

Further, stress-directed maturation trajectories may be found in many dissociative and early traumatized patients. They often reach puberty sooner than their cohorts and may actively seek multiple sexual partners while fearing long-term commitment to one partner (Kofman, 2002; Lyons-Ruth, Yellin, Melnick & Atwood, 2003; Lyons-Ruth & Jacobvitz, 1999; Schmahl, Elzinga & Bremner, 2002). Many have a history of early and unwanted pregnancies and some young fathers and mothers, not interested in parenting, abandon their children to other family members or the social service system. These same patients, accurately and inaccurately, are biased to detect threat and seem to continually react to one crisis after another (Kluft, 1990; Putnam, 1997; Schmahl, Elzinga & Bremner, 2002). The mandate to survive is often the dominant force in their lives. For dissociative patients with prenatal and postnatal abuse and neglect, the defensive and reproductive strategies may be reinforced by ongoing experiences of harsh childhood environments.

CONCLUSION: INTEGRATING REGULATION VS. DISINTEGRATING DYSREGULATION

Prenate vulnerability to maternal stress is sobering. The research findings are strong, but equally strong is the data demonstrating what happens when prenatally stressed newborns are adopted by secure regulated and attuned parents (Cameron et al., 2005; Dozier, 2005), or when high-risk parents enter early intervention programs (Field, 2001; Urizar et al., 2004). This can positively change an offspring's developmental trajectory. With consistent, attuned and nurturing caregiving, especially if there is adequate physical affection and contact, the stress systems and the ANS may be modified (Cameron et al., 2005; Card et al., 2005; Cassidy & Shaver, 1999). These modifications may occur not just at the behavioral level, but also at the neurobiological level (McEwen, 2003a; Schore, 2003). Early movement programs for young children that facilitate the integration of primitive reflexes into more complex motor behavior have also proven to enhance L-ANS development (Taylor et al., 2004), including greater heart rate variability and vagal tone (Bazhenova, Plonskaia & Porges, 2001). Healing a dysregulated infant or toddler may occur when the experience-dependent maturation process is facilitated by a caregiving environment that provides appropriate pacing and relational attunement (Bakermans-Kranenburg, van Ijzendoorn & Juffer, 2005; Chryssanthopoulou, Turner-Cobb, Lucas &

Jessop, 2005; Dunn, 2004; Field, 2001; Porges, 2004). And for the pregnant mother, treatment interventions that include stress reduction instruction (Urizar et al. 2004), massage, acupuncture (Field et al., 2006) or careful pacing, attunement and regulatory support in psychotherapy treatment may reduce prenatal stress and facilitate enhanced prenatal development.

This article presents a prenatal relational model where experience-dependent dyadic interactions between mother and prenaté may shape the offspring's limbic-autonomic and sensorimotor systems. Prenatal stress may activate the early forming prenatal stress systems, including defensive 'fixed action patterns.' Lasting effects may persist beyond prenatal development and may remain as non-verbal neurobiological and physiological sensorimotor stress behaviors (Bornstein & Lamb, 2005). It is hypothesized that when prenatal development is marked by chronic maternal stress, primitive defensive reflexes may become indelible 'fixed action patterns' that are readily mobilized. Early prenatal experience may persist, and may be a variable, along with genetic heritability, that contributes to development. This can be seen in studies of identical twins separated at birth who not only share identical genetic heritability but also similar prenatal experience. Perhaps their prenatal experience also informs the surprising similarities in their life trajectories despite very different infant-childhood caregiving environments (Johnson et al., 2000).

Maternal events such as domestic violence, depression, self-injurious behavior and unregulated posttraumatic stress symptoms, including dissociation, may seriously jeopardize the maturing prenatal (Field & Tronick, 1986; Kofman, 2002; Lundy et al., 1999; McEwen, 2003b; B. M. Newman & P. R. Newman, 2005). When stressed prenates enter extrauterine life, interacting with dysregulated and misattuned caregivers, may reinforce their defensive 'fixed action patterns.' With a history of prenatal stress, dysregulated children and adults, if left untreated, may remain easily overwhelmed by normal environmental stimuli. Based on clinical observation individuals with histories of prenatal, neonate and childhood stress often react with anger and frozen tension when they hear an unexpected sound or they get easily irritated by something as common as the sound of someone chewing food or swallowing fluids. They may reject certain foods or clothing because of extreme aversive responses to particular smells or textures (Desantis, Coster, Bigsby & Lester, 2004). It is easy to identify their dysregulation. Their skin color changes rapidly, their heart rate and breathing fluctuate outside the normal range, and they are quickly distressed by tempera-

ture changes. They grimace, their body posture is either tense or collapsed, and they often feel intense nausea or dizziness. They are not able to concentrate, which compromises learning, and they do not get adequate rest. They cannot tolerate disappointment and are filled with intense, unmodulated and overwhelming emotions of fear, anger or sadness. Joy and contentment are seldom part of their daily experience. When parent and child both suffer the same dysregulation, it is almost impossible to develop organized coherent attachment strategies (Blizard, 2005).

This dysregulated generational cycle may be perpetuated unless self-regulation is promoted, especially during prenatal development. Not only may stressed prenatates' primitive defensive reflexes be overactive but their brains may re-organize to ensure survival of the species. Defensive, mating and caregiving behavior may be prenatally biased towards living in a threatening world. As clinicians, knowledge of these alterations may guide us to develop early intervention protocols. Ideally, therapeutic treatment should reduce the pregnant patient's physiological and psychological stress systems. Attention to resolving dissociative and trauma symptoms of the patient should not supercede the issues of regulation. Hopefully interventions during this period can minimize negative effects on the prenatate.

For many dissociative disordered patients, even their prenatate experience was dysregulating. Once their defensive reflexive physiological behaviors are reduced, new self-regulating physiological states may emerge. The ultimate treatment goal is to change their neurobiological defensive, mating and caregiving systems. Hopefully through treatment the stress-inhibiting hippocampal and GABA systems may be mobilized and new oxytocin receptor sites in the preoptic nucleus of the hypothalamus begin to sprout. With these potential neurobiological changes, including greater cortical and sub-cortical regulation of the defensive reflexes, mother and prenatate/neonate may begin to enjoy interactions that are no longer fraught with distress—the generational transmission of threat may gradually dissipate.

Maternal stress has a powerful influence on the prenatate. This article presents a prenatal relational model that illustrates the intricate connection between mother and offspring. It offers a developmental perspective that includes long-lasting effects of chronic prenatal stress that may impact the trajectory of neurobiological systems over the course of the life span. Through interdisciplinary evidence, it is suggested that prenatate experience may be stored in bodily-based implicit memory, since primitive defensive reflexive 'fixed action patterns' incorporate a

complex sequence of cascading neurochemical, sensorimotor and emotional behaviors. The prenatal relational model suggests that maternal stress alters the prenatate's L-HPA and the L-ANS. Although they may be accessible to change, this model posits a concordant pattern of maternal-prenate instability. Further, not only anxiety, depression and anger (Field et al. 2003) but also posttraumatic stress and dissociation in the mother may effect the neurobiology of the prenatate.

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