Environmental factors affecting the nervous system and health: The prenatal and perinatal period

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Somatic Psychology Theory as a Mode for Understanding the Origins of Chronic Illness: A Case Study of Type 1 Diabetes

Chapter 2: *Literature Review: Prenatal and Perinatal Environment*

Abstract

This article presents data from a number of researchers in the fields of fetal programming, prenatal and perinatal psychology, neurophysiology, and development including Thomas Verny, Peter Nathanielsz, Marshall Klaus and John Kennell. This data increasingly supports the findings that the prenatal and perinatal environments play a role in affecting risk for adult health and disease. Stress and other factors during early life, for example, influence developing organ systems such as the nervous system, and can affect receptors and physiological regulatory processes in ways that last into adulthood. The prenatal and perinatal environment also influences the quality of bonding and attunement between mother and infant. The attachment bond has been shown by Allan Schore and others to play a vital role in gene-environment interactions involved in shaping the nervous system during the first 3 years of life.

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Introduction

The perinatal period, which begins at around 28 weeks of prenatal life until 4 weeks after birth, and the prenatal period prior to that are associated with intense growth of many organ systems (Moore & Persaud, 1998). This growth occurs in conjunction with an extreme degree of vulnerability as the result of total dependency on the adult caregiver (Klaus & Kennell, 1976). According to concepts that have been previously presented, the fetus and very young infant could be expected to be highly subject to environmental influences during this time, whether in a manner that supports optimal development or that facilitates predisposition to ANS imbalance. Findings from the literature confirm this association.

This section builds on the literature review presented to date regarding the influence of trauma and the caregiver-infant bond in shaping the regulatory capacity of the nervous system. The goal is to highlight salient features describing the manner in which experience affects nervous system development in this early time period. These influences are similar to concepts previously elucidated.

Prenatal Life

Brain Development

The three main parts of the brain form by 28 days after conception (Verny, 2002) and consist of the hindbrain, the midbrain, and the forebrain, from which the cortex develops (Moore & Persaud, 1998). The nervous system begins to form at an even earlier age, however, and arises from the neural tube (Moore & Persaud, 1998). The neural tube, like all other cells and structures in the human being, undergoes programmed genetic development that begins with the mixing of the material between the sperm and the egg (Caldwell, 2001; Verny, 2002). If one applies Schore's (1994) well-developed principle that environmental factors influence structures that are undergoing active development, "experience" may be perceived as having the potential to impact nervous system growth from the moment of conception, if not before.

Emotions and Response to Stimuli

Research performed by former Harvard professor Jason Birnholz (1989, as cited in Verny, 2002) demonstrates that unborn babies express emotional reactions. This finding is based on an evaluation of over fifty thousand ultrasounds performed by Birnholz on unborn babies. By four months of age, an unborn child "plays with her umbilical cord and sucks her thumb", grimaces and cries if an unpleasant tasting substance is introduced into the womb, and swallows at twice the normal rate if it is instead a sweet-tasting substance (Verny, p. 30). In addition, defensive postures are present and "at five months the same child will react to a loud sound by raising her hands and covering her ears" (Verny, 2002, p. 30).

Schore's (1994) work specifically implicates the right cortex and limbic system in the capacity of the organism to respond to the socioemotional environment (1994). The existence of an emotional valence in the experience of prenates supports Schore's work on attachment, suggesting that ANS structures, as well as regulation and balance, are also influenced in the prenatal time frame.

> Awake or asleep, [prenates] are constantly tuned in to their mother's every action, thought, and feeling. From the moment of conception, the experience in the womb shapes the brain and lays the groundwork for personality, emotional temperament, and the power of higher thought (Verny, 2002, p. 29).

Memory

Scientific studies have demonstrated that babies remember events from their time in utero (Verny, 2002). One such study, conducted by psychologist Anthony deCasper (1980, as cited in Verny, 2002) of the University of North Carolina, measured whether stories read by mothers to their unborn

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children in the last 6 weeks of pregnancy could be identified by their babies after birth. For this study, deCasper invented a measurement device called a suck-o-meter.

> The suck-o-meter□ [is] a nipple on a baby bottle connected to a computer-controlled tape player. [In the experiment] newborns could switch between two taped stories, both recorded by their mothers, simply by changing their sucking rhythm. … When the babies were tested within a few hours of birth, thirteen of sixteen adjusted their sucking rhythm to hear the familiar story (deCasper, 1980, as cited in Verny, 2002, p. 30).

In addition to the fact that so many babies clearly demonstrated recollection of specific stories, it would be interesting to know why three did not respond with a change in sucking rhythm. Perhaps a perinatal event interfered with their memory, or perhaps their inability to respond relates to their capacity to adapt to their environments rather than to lack of memory. From this and other studies, however, it is now evident that babies, children (Chamberlain, 1990), and adults (Janov, 1983; Sinclair Lister (host), 1983; Verny, 2002), can remember experiences from prenatal life.

The storage of prenatal memories is relevant to previous discussions on the socioemotional development of the nervous system and trauma, which describe the amygdala as a vital organ for the storage and assessment of arousal-based experiences. "The emotional content and meaning of sensory input are assessed by the right amygdala, which essentially attaches emotional valence … for the purpose of further processing by the hippocampus and orbitofrontal cortex" (Ledoux, J., 1986, as cited in Scaer, 2001, p. 10). Although both the hippocampus and amygdala begin to develop prenatally, the amygdala matures more quickly and is closer to fully formed at birth (Cahill, L et al., 1994, as cited in Goleman, 1997, p. 22; Jacobs & Nadel, 1985, as cited in LeDoux, 1996, p. 205-6).

The amygdala, the center of memory as it pertains to arousal (Scaer, 2001), connects to the orbitofrontal cortex directly through one synapse (Goleman, D., 1997), implying a strong link to this regulatory center. Memories associated with states of arousal that occur in the prenatal time frame thus appear to be stored, at least in part, in the amygdala.

The critical period of maturation for the amygdala occurs during the last trimester of pregnancy and continues through the first two months following birth (Panksepp, 1998, as cited in Schore, 2001a, p. 22). According to Schore's concepts, this suggests that prenatal events, as well as the experience of labor, birth, and early bonding, are registered in and influence the growth of the amygdala if arousal levels are sufficiently intense. The process of birth is inherently stressful and is associated with high states of arousal (Lagercrantz & Slotkin, 1986).

The Experience of Pain and Stress

Prenates have all of the necessary nervous system wiring required to experience pain by the age of 16 weeks. Connections between peripheral tissues form at 8 weeks, however, and these connections are more or less complete by 28 weeks (Anand, K. and Hickley, P. 1987, as cited in Verny, 2002, p. 34). In addition, evidence suggests that "inhibitory pathways that block incoming pain do not develop until after birth" (Fisk, N., and Glover, V, 1999, as cited in Verny, 2002, p. 35). This finding is consistent with Schore's assertion that inhibitory systems are immature at birth and mature more slowly than mobilization systems (Schore, 1994).

Other studies demonstrate that the unborn baby has a significant response to stress as evidenced by increases in norephinephrine, endorphins, and cortisol "in response to trauma" (Verny, 2002, p. 35). In addition, exposure to prenatal stress can influence the developing brain in ways that continue into adulthood.

> Prolonged exposure to stress hormones, including adrenaline [epinephrine] and cortisol, prime the growing brain to react in fight-or-flight mode — even when inappropriate — throughout life. Maternal … joy and

> love, on the other hand, bathes the growing brain in "feel-good" endorphins and neurohormones such as oxytocin, promoting a lifelong sense of well-being. (Verny, 2002, p. 38).

Pregnant women have long reported an increase in fetal movement in association with stress, and this has been documented in fetal ultrasound studies of stressful procedures such as amniocentesis (Verny, 2002). Evidence for fetal stress has also been studied with respect to fetal heart rate during times of maternal stress. One study found that:

> fetal heart rates were raised significantly and stayed high longer in expectant mothers with the highest levels of stress hormones, who reported feeling the most anxiety and the least support. Women with wanted pregnancies, good self-esteem, and sufficient social support had the calmest babies, whose heart rates returned to normal in the shortest time (Wadhwa, P., 1993). Prolonged fetal heart rate reactions … have been linked in other studies, to increased risk for heart disease and diabetes in later life" (Verny, 2002, p. 40).

The impact of stress in the prenatal environment is associated with the degree to which mothers experience stressful events during pregnancy, and affects the birthweight of the baby as well as the duration of pregnancy. Sandman, Wadhwa and colleagues (1998, as cited in Verny, 2002) studied 90 women with respect to five criteria for stress:

1) life-event changes, which referred to such experiences as change in job, residence, or marital status;
2) daily hassles such as being short of money or feeling overworked;
3) chronic stress, described in women who felt continually anxious in response to daily life events and who reported life as unpredictable and uncontrollable;
4) psychological and physical symptoms such as backache, depression, and nervousness;
5) pregnancy-related anxiety, such as maternal fears concerning the health of her baby, labor and delivery, and relationships with health care providers.

The findings from this study were that "women who reported a higher level of life-event stress were more likely to deliver low-birth-weight babies, and those with high levels of pregnancy anxiety were likelier to give birth at an earlier gestational age (Wadha, 1998, as cited in Verny, 2002, p. 41). Factors that conveyed protection in women who experienced stress included their emotional support system.

A study of 1,123 pregnant women conducted by Zuckerman and colleagues (1990, as cited in Verny, 2002) showed that when women are depressed during pregnancy, their babies cry more and are more difficult to console. Furthermore, "the more depressed the mother, the more irritable the newborn" (Verny, 2002, p. 46). Women who report depression and anxiety in very early pregnancy more frequently have babies that have low Apgar scores [a measurement tool used to evaluate the health and status of a newborn at 1 minute and 5 minutes after birth] and that need resuscitation after birth (Verny, 2002, p. 46). Depression is an emotion associated with parasympathetic dominance and the immobility response, and perhaps plays a role in lower newborn apgar scores.

Fetal exposure to stress can lead to a permanent state of insensitivity to stress-related chemicals such as CRF, ACTH, endorphins, and cortisol, and exposure in early life reprograms the HPA axis (Nathanielsz, 1999). Furthermore, the effects of stress vary depending on the timing of exposure. According to Schore's concepts, effects of timing may influence developing structures.

> When mothers had greater stress in the third trimester [6 to 9 months] of pregnancy, the unborn child was more likely to continue to react to repeated stimuli, as measured through the fetal heart rate. Unborn children with calmer mothers, on the other hand, tended to habituate to repeated

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> exposure to the same stimulus, reacting less strongly as time went on (Verny, 2002, p. 43).

Fetal Programming

> Programming is the process by which stimuli in fetal life permanently alter tissue structures, metabolic and physiological functions, and even gene expression. Although numerous examples of this phenomenon have been identified in the natural world and in experimental animal models, the significance of fetal programming for human health processes has only recently been identified .... It is becoming clear that factors encountered *in utero* may 'programme' the fetus to become susceptible to disease in adult life (Langley-Evans, 1997, p. 88).

Fetal programming is an area of study that has identified strong correlations between measurements of newborns at birth, such as weight and abdominal girth, and adult disease (Nathanielsz, 1999). This area of study was initiated by English physician David Barker and is based on documentation of birth measurements obtained from sets of tens of thousands of birth records found intact in individual community registers (Nathanielsz, 1999). In these studies, adults were traced from information in their birth records, which were twenty or thirty years old, and correlations were identified between birth measurements and diseases identified in the adults. The types of illnesses that correlated with the birth data were diseases of insulin resistance such as type 2 diabetes, obesity, and heart disease. "A man who weighed less than 5.5 pounds at birth has a 50 percent greater chance of dying of heart disease than a man with a higher birth weight, even accounting for socioeconomic differences and other heart risks" (Begley & Underhill, 1999, p. 53).

Findings in fetal programming suggest that the prenatal environment influences development of adult disease. These birth measurements appear to be influenced by prenatal stress, including but not limited to, malnutrition (Nathanielsz, 1999). Furthermore, fetal programming is also thought to affect genetic expression (Nathanielsz, 1999). Interestingly, fetal programming theorists suggest that it is not *exposure* to stress as much as the *response* to stress that appears to be important in generating disease and influencing genetics (Nathanielsz, 1999). The individual response to threat, which has been presented as a concept in attachment and trauma theory, also appears to be present in prenatal life.

Glucocorticoids are stress hormones that get their name from their ability to affect glucose levels (Selye, 1978). Cortisol, which has been mentioned earlier in relationship to the HPA response to acute stress and the chronic response seen in PTSD (where cortisol levels are often low), is a glucocorticoid. In the fetus, glucocorticoids play a key role in glucose metabolism and in the maturation the liver, kidneys, and immune system, among others (Nathanielsz, 1999). These stress hormones are also "extremely potent regulators of gene expression, growth, and tissue maturation" (Langley-Evans, 1997, p. 89).

As mentioned above, prenatal stress influences cortisol levels and may permanently reprogram the HPA axis (Nathanielsz, 1999). Elevations during the prenatal time frame are associated with permanent changes in the nervous system and affect future ability to respond to stress. Smaller size at birth has been associated with higher cortisol levels in adults and higher cortisol levels in adults are associated with diseases of decreased glucose tolerance (Clark, 1998) such as type 2 diabetes.

Nathanielsz (1999) describes ten principles of programming that relate to events occurring during the prenatal period. Some of these are very similar to concepts presented by Schore (1994) regarding the influence of attachment on nervous system development, and six of the most relevant principles are presented below.

1) "There are critical periods of vulnerability to suboptimal conditions" (p. 31);
2) "Programming has permanent effects that alter responses in later life and

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can modify susceptibility to disease" (p. 31);

3) Each phase of fetal development provides the required conditions for the next;
4) Programming involves structural changes associated with tissue growth as well as programmed cell death (apoptosis) such as pruning;
5) "The effects of programming may pass across generations by mechanisms that do not involve changes in the genes" (p. 31);
6) "Programming often has different effects in males and females" (p. 31).

While the pathophysiology of fetal programming remains unclear, data suggests that the fetus learns to defend itself in utero (Nathanielsz, 1999). This process appears to strongly affect the manner in which the infant copes with similar situations after birth (Nathanielsz, 1999).

Fetal exposure to stress is associated with increases in fetal movement, heart rate, and circulation of catecholamines and is known to affect the wiring of the brain in ways that can be long lasting. These findings appear consistent with material presented by Allan Schore (1994) on the experience-dependent maturation of the nervous system and by Robert Scaer (Scaer, 2001) on the short and long-term effects of undischarged trauma.

> Excessive exposure to stress affects the physiology of the brain. Changes … include destruction and inhibited growth of neurons and synapses in the area of the hippocampus and a decrease in the production of certain neuroreceptors. In the susceptible individual, prenatal stress causes a real rewiring of the brain, setting the stage for stress-prone reactions, from heightened irritability to behavior problems throughout life (Sandman, C., Wadhwa, P., Chicz-DeMet, A., Dunkel-Schetter, C., and Porto, M., 1997, as cited in Verny, 2002, p. 43).

In addition, changes that reprogram the HPA axis of female infants is known to alter their offspring's HPA axis in a "transgenerational transmission of the adrenal hyperactivity" (Nathanielsz, 1999, p. 19). Changes that occur before birth are now known to have far-reaching consequences and the pathophysiology of this process is becoming increasingly clear.

Perinatal Events: Bonding

Prenatal experiences influence the ability of the mother and infant to bond after birth, and the quality of this bond affects the attachment and attunement in the first years of life (1994). Early bonding, however, is also vital in its own right as a critical factor involved in shaping ANS development. Bonding is affected by a large number of maternal as well as infant-related factors and the degree to which a mother bonds affects her ability to care take her infant (Klaus & Kennell, 1976).

This section is based on work done by two pediatricians, Marshall H. Klaus and John H. Kennell and, unless otherwise stated, refers to their work as presented in their 1976 book "*Maternal-Infant Bonding: The Impact of Early Separation or Loss on Family Development*". The studies on which this book is based are still highly relevant and were conducted during a time when separation of infant and mother at birth was routine practice. While early separation is still common practice in many hospitals despite this knowledge, there are now more opportunities to minimize separation.

Studies examined mothers and babies in routine settings and used them as a control group to compare the effects of interventions in which mother-infant pairs in the experimental groups were allowed to spend more time together at birth and/or in the initial days following birth.

Maternal Caretaking

Maternal caretaking skills are influenced by the mother's set of life-experiences (Brazelton & Cramer, 1990; Klaus & Kennell, 1976), the manner in which she was raised by her parents, whether or not her parents separated at an early age when raising her, and the degree to which she bonds to her baby

(Klaus & Kennell, 1976). The mother's capacity to bond, in turn, is influenced by a variety of factors that impact one or both partners of the mother infant pair. Some of these factors (Klaus & Kennell, 1976) include the following:

1) the mother and infant's experience of pregnancy, including whether or not it was planned;
2) whether the pregnancy occurs in the context of a supportive relationship, which can buffer the mother's responses to stress;
3) her response to the awareness of her fetus as a separate individual, which occurs when she begins to feel his or her movements;
4) levels of stress during pregnancy;
5) the experience of labor and delivery;
6) whether mother and baby are separated at birth, and for how long.

Bonding

Maternal-infant bonding is a "natural, biological occurrence" that occurs if mother and infant are allowed to be together immediately after birth (Madrid & Pennington, 2000). However, the quality of this bond and the degree to which it occurs are affected by circumstances that surround the prenatal and perinatal period, many of which are outside the conscious control of the parents-to-be.

Experiences of the mother during pregnancy are one of the factors that affect her capacity to bond with her baby after birth and may be especially important if impediments to bonding occur following labor and delivery. Stress during pregnancy is one important risk factor that influences this capacity to bond (Klaus & Kennell, 1976). Prenatal stressors include emotional factors that block out bonding emotions and can be the result of:

> moving to a new geographic area, marital infidelity, death of a close friend or relative, previous abortions or loss of previous children, which leaves the mother feeling unloved or unsupported or which precipitates concern for the health of either her infant or herself may [sic] delay preparation for the infant and retard the bond formation (Cohen, 1966, as cited in (Klaus & Kennell, 1976).

Indeed, intense fear, severe depression, and extreme marital problems can compete with the emotions involved in bonding (Madrid & Pennington, 2000), and can also affect future generations. Pain is another factor that decreases a mother's availability for bonding (personal communication, Antonio Madrid, July 17, 2002).

Transgenerational effects of emotional events in pregnancy can also occur (personal communication, Antonio Madrid, July 17, 2002). Verny cites the work of California psychologist Gail Peterson (1994, as cited in Verny, 2002), who states that the emotionally devastating loss of an unborn child in the perinatal period can affect future generations. Citing Peterson, Verny explains that "women can absorb during childhood the impact of their *mother's* prenatal loss and are particularly vulnerable to high levels of fear during their own pregnancy, childbirth, and the ongoing parent-child relationship" (p. 50).

The period immediately following the birth of a baby, described as the postpartum period, strongly impacts the degree to which the maternal-infant bond develops, especially in the first minutes and hours. This period is designated as a "*sensitive period*… which is optimal for parent-infant attachment" (Klaus & Kennell, 1976, p. 66). One study mentioned by Klaus and Kennell (Klaus, M., Jerauld, R., Kreger, N., McAlpine, W., Steffa, M. and Kennell, J, (1972), demonstrates the degree of impact that optimization of this experience can have.

> In one carefully controlled investigation involving primiparous [first-time] mothers with normal full-term infants, an 'early and extended-contact' group of fourteen mothers was given their nude babies in bed for 1 hour in the first 2 hours after birth and for 5 extra hours on each of the next three days of life. The other group of fourteen mothers received the care that is routine in most United

> States hospitals: a glimpse of the baby at birth, a brief contact for identification at 6 to 8 hours, and then visits of 20 to 30 minutes for feedings every 4 hours. The groups were matched as to age and marital and socioeconomic status of the mothers, and they were not significantly different in the sex and weight of the infants. Women were randomly assigned to groups, given the same explanation of the study, and to the best of our knowledge, were not aware that there were differences in mother-infant contact in the first three days (Klaus & Kennell, 1976, p. 54).

In this study, infants were examined and the quality of mother-infant interactions was evaluated each year over five years, beginning one month following hospital discharge. Interviews as well as direct and videotaped observations were used to identify potential differences between groups. At one month, extended contact mothers "were more reluctant to leave their infants with someone else and usually stood and watched during the physical examination. They showed more soothing behavior when their babies cried during the examination" (p. 55). In frame-by-frame evaluation of mothers feeding their infants, it was noted that

> although the amount of time the mothers in each group spent looking at their babies was not significantly different, the extended contact mothers showed significantly more *en face* (11.6% in experimental mothers compared with 3.5% in control mothers) and fondling (6.1% compared with 1.6%) than did control mothers. No significant differences in measures of caregiving were noted, although the bottle was held away from the perpendicular more often in the control group" (p. 57).

Significant differences were still observable at one year after birth, in that "extended contact mothers spent a greater percentage of time near the table assisting the physician while he examined their babies and soothing them when they cried" (p. 57). At two years,

> extended contact mothers asked twice as many questions and used more words per proposition, fewer content words, more adjectives, and *fewer commands* [italics added] than the control mothers. At five years, … children of the early contact mothers had significantly higher IQ and more advanced scores in two language tests (Ringler et al.,1976 as cited in Klaus and Kennell). These findings suggest that just sixteen extra hours of contact within the first three days of life affect maternal behavior for one year and possibly longer, and they offer support for the hypothesis of a maternal sensitive period soon after birth …. [Of note], the experimental groups of mothers and infants were actually separated from their infants at birth. The baby was placed with the mother 1 to 2 hours after birth and did not remain with her constantly from birth as in a natural home birth situation. The amount of anesthesia and drugs given to the mothers in this study would be considered minimal for primiparous mothers in a university hospital setting, but the mothers and infants in both groups did receive medication that may have influenced the effects of the early contact (Klaus & Kennell, 1976, p. 59).

Another study (Klaus, Kennell, Mata, Sousa, and Urrutia, 1974, as cited in Klaus & Kennell, 1976) was conducted to examine the effects of early contact on breastfeeding. Mothers in one hospital were given their babies to hold in skin-to-skin contact immediately after birth for 45 minutes. Mothers and infants in the control group were separated at birth, as was customary in both hospitals. Both groups otherwise received the same care, and were given their babies at 24 hours to breastfeed. Mothers were reevaluated with respect to breastfeeding status at an unspecified time, perhaps at 6 months.

> Significantly more mothers were still breastfeeding and there were fewer episodes of infection in the early contact group. Six months after birth, the mean weight gain of the infants in the early contact group was 761 grams, or nearly 1 1/2 pounds greater than that of the infants in the control group ($p < .05$) (Klaus & Kennell, 1976, p. 61).

Klaus and Kennell cite data from De Chateau in Sweden (1976, as cited in Klaus & Kennell, 1976) regarding a study of the impact of skin-to-skin contact for 30 minutes immediately following birth in the experimental group when compared to the control.

> Mothers who had early contact spent significantly more time in the *en face* position and kissing their infants, whereas the control mothers often cleaned their infants. The two groups appear to focus on different ends of the baby. One group was busy cleaning up whereas the other was giving love. A striking finding was that infants of early-contact mothers cried less and smiled and laughed significantly more than did infants of control mothers. Mothers given extra contact breastfed longer than did controls (mean: early contact, 175 days; controls, 108) (Klaus & Kennell, 1976, p. 63).

Paternal caregiving is also influenced by early contact and "was greatly increased when the father was asked to undress his infant twice and to establish eye-to-eye contact with him for 1 hour during the first three days of life" (Klaus & Kennell, 1976, p. 65).

Mothers who are bonded to their infants tend to hold them more frequently in the "en face" (face to face) position, and to hold their babies in their left arms. They also breast feed more often, for longer periods during each breastfeeding episode, and for a greater overall length of time. The effects of early exposure and bonding can have long-lasting impacts.

Interactions that promote bonding.

Certain innate behaviors have been found to promote the formation of the maternal-infant bond during the sensitive period. During this brief window in time, circulating hormones in the mother's blood contribute to an environment of deep interest and attraction. Suckling and touch by the baby, whether or not it is associated with breastfeeding, can induce increases in maternal levels of oxytocin and prolactin. Oxytocin promotes uterine contractions that minimize bleeding after birth, and is associated with a sense of "safety" (Porges, 2001). Oxytocin is also "critical for affiliative behavior" (Henry & Wang, 1998, p. 863) and maternal bonding (Kendrick, 2000), and is thought to play an important role in the survival strategy associated with social bonding (Taylor et al., 2000; Turner, Altemus, Enos, Cooper, & McGuinness, 1999). Indeed, one study of oxytocin levels in human mothers shows that levels increase for 60 minutes after birth, and then return to prebirth levels (Nissen, Lilja, Widstrom, & Uvnas-Moberg, 1995). Prolactin is considered to be a "love hormone" and may therefore increase attachment between mother and infant (Klaus & Kennell, 1976, p. 79).

Another factor is sometimes referred to as a "magical presence" associated with birth. This atmosphere is generated in the delivery room and attracts those who are present to the newborn. This effect is described as an evolutionary strategy aimed at ensuring sufficient attachment with an adult caregiver in the event that the mother dies in childbirth.

Qualities in the baby also promote the bond during the sensitive period. In the sensitive period, the baby is frequently in a quiet, alert state for 45 to 60 minutes of the first hour after birth. When describing this alert state, Klaus and Kennell (1976) refer to the baby as being "ideally equipped for the important first meeting" (p. 66). Indeed, in this alert state, the newborn "is ready to respond to the mother, to dance in rhythm to her speech or movements" (Cassel & Sander, 1975, as cited in Klaus & Kennell, 1976, p. 75). This quiet alert state appears to correspond with previously described states of parasympathetic receptivity (Schore, 1994).

Following the initial hour of quiet alertness, babies go into a deep sleep for three to four hours. Afterward, they only enter the alert state for a few seconds at a time in the first few weeks of life. The degree to which this alert state "co-occurs" with maternal presence, however, increases with the amount of time a mother holds her baby. During the first week the frequency with which the infant enters this alert state while being held can increase from "less than 25% on the second day to 57% … on the eighth day" (Cassel and Sander, 1975, as cited in Klaus and Kennell, 1976). The amount of time that the mother spends holding her infant, as well as the manner in which she holds him, is influenced by the degree to which she has bonded to her baby.

Additional factors that influence the maternal-infant bond in the first minutes, hours, and days of life include touch and eye contact. Touch facilitates bonding particularly when there is skin-to-skin contact although it is still impactful when the baby is clothed. Eye contact plays a similar role to that described in the attachment period by Schore (1994). Infants can see, even at birth, and "the infant of an unmedicated mother will easily follow a moving hand at a 12- to 15- inch distance" (Brazelton, 1966, as cited in Klaus & Kennell, 1976, p. 71). The appeal of eye contact and the quality of gaze interaction described by Klaus and Kennell is similar to that presented by Schore (1994). During this period, mothers express an intense interest to see their waking infant with eyes open and this experience is further described as being rewarding.

Influence of the bond on the infant's ANS.

Caregivers play an important role in helping the infant establish rhythms in early life. Entrainment, in which sound and movement are used in an intricate dance of communication between caregiver and infant, represents one such pattern.

> When a person speaks, several parts of his body move in ways that are sometimes obvious and sometimes almost imperceptible; the same is true of the listener, whose movements are coordinated to the elements of the speech. When two people are filmed, the microanalysis reveals that both the listener and the speaker are moving in tune to the words of the speaker, thus creating a type of dance …. Newborns also move in time with the structure of adult speech …. Although the infant moves in rhythm to his mother's voice and thus may be said to be affected by her, on the other hand the infant's movements may reward the mother and stimulate her to continue. The point is that these areas of contact are interactive (Klaus & Kennell, 1976, p. 73-4).

After birth, rhythms established by the baby in the womb are disrupted as he or she adapts to his new environment (Sander, 1970, as cited in Klaus & Kennell, 1976). Synchronous movements between mother and infant, as well as a steady routine, help the infant reorganize, retrain, and reestablish the "biorhythmicity" needed to adapt to his extra-uterine environment (Klaus & Kennell, 1976, p. 74). Entrainment and rhythmicity appear to influence a number of activities in the baby including the autonomic processes involved in circadian rhythms. The manner by which this occurs resembles the role of interactions between mother and infant in the attachment period depicted by Schore (1994). In this early time frame, maternal-infant interactions seem to influence more primitive functions of the nervous system, commensurate with structure development that takes place at this time.

Influences of separation on bonding.

Studies cited above demonstrate the deep impact of bonding on the developing infant and suggest that separation can have long-lasting consequences. Separation at birth has been (and continues to be) a common occurrence in hospitals in the United States, and occurs for a variety of reasons, including as part of common treatment approaches for health issues that occur in this time period.

> Affectional ties can be easily disturbed and may be permanently altered during the immediate postpartum period. Relatively mild illnesses in the newborn, such as slight elevation in bilibrubin levels, slow feeding, additional oxygen for 1 or 2 hours, and the need for incubator care in the first 24 hours for mild respiratory distress, appear to affect the relationship between mother and infant. The mother's behavior is often disturbed during the first year or more of the infant's life, even though his problems are completely resolved prior to discharge, and often within a few hours (Rolnick, 1960, as cited in Klaus & Kennell, 1976, p. 52).

The bond between mother and infant is seen in other species, and the degree to which separation influences this attachment varies. Some mammals reject their pups entirely if their pups are removed during the sensitive period following birth. While humans do not usually "reject" their young outright, they may feel distinctly and confusingly uninterested.

> When the separation is prolonged, mothers report that they sometimes forget momentarily that they even have a baby. After a premature baby has gone home, it is striking to hear how often the mother reports that, although she is fond of her baby, she still thinks of him as belonging to someone else – the head nurse in the nursery or the physician – rather than herself (Klaus & Kennell, 1976, p. 51).

In fact, mothers "are often ashamed of this lack of attachment and blame themselves for it. They have no idea why they feel detached from their child" (Madrid & Pennington, 2000, p. 279). In addition, they are sometimes blamed by others who remain ignorant of the impact of the sensitive period on bonding.

Additional factors that can disrupt the maternal-infant bond include procedures and interventions performed during labor and delivery such as anesthesia, induction of labor using synthetic oxytocin, forceps, and cesarean sections (Madrid & Pennington, 2000; Verny, 2002). Other conditions that influence the capacity to bond include adoption, illness in the mother, multiple babies such as twins and triplets, and "the circumstances when the mother first touches her child"(Madrid & Pennington, 2000, p. 285).

The degree of maternal motivation to bond may help the connection develop even in the event of separation and other disruptions (Madrid & Pennington, 2000). The possibility of bonding occurs even in adoptions, where both sets of parents may find themselves dreaming of the child and talking to it before it is born (Madrid & Pennington, 2000).

Illness and separation in early life.

The impact of disruptions in bonding in early life may influence risk for physical diseases such as asthma. Antonio Madrid (Madrid, Ames, Skolek, & Brown, 2000), a psychologist who utilizes hypnotherapy, has conducted studies that demonstrate an increased incidence of bonding disruptions in asthmatic children. In one such study, children with asthma had a 70% incidence of nonbonding events in early life in comparison with 20% in a control group. Madrid cites additional studies that show a similar history of bonding disruptions and separations in asthmatic children (Feinberg, 1988; Schwartz, 1988, as cited in Madrid, Skolek, & Ames, 2003). A recent medical study shows an increased history of obstetrical interventions at delivery in asthmatic children (Xu, Pekkanen, & Jarvelin, 2000).

Porges (2001)postulates that asthma, which is a disease caused by the frequent tightening and narrowing of the bronchi (the breathing tubes that connects to the lungs), may be the result of a dorsal vagal (DVC) parasympathetically mediated component of the freeze response. In his article, Porges states that constriction of the bronchi helps conserve oxygen and that asthma may be the result of an attempt to adapt using the freeze response at birth. If one combines these two theories, it is possible to consider that separation at birth may be associated with an overwhelming experience that results in the

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freeze response.

In a series of fascinating studies following an unanticipated outcome in his private practice, Madrid demonstrates that conducting hypnotherapy with the *mother*, in which he walks her through a "perfect birth", can result in significant improvement or resolution of asthma in the *child* (Madrid, 1991; Madrid & Pennington, 2000; Madrid et al., 2003). These findings may relate to the strength of the maternal-infant bond that exists even when a mother and child are not in contact, and which is alluded to by Schore (1994).

It would be interesting to once again consider Schore's perspective that environmental events influence structures in critical or important phases of development as a means from which to consider the potential influence of perinatal events on health and disease. A number of organs and tissues undergo a dramatic change in function as the neonate progresses rapidly from her water world in which almost all needs have been taken care of through the placental connection with her mother. As the newborn enters the extrauterine environment, her lungs begin the work of breathing air, circulation changes dramatically as the heart and blood vessels adapt blood flow to utilize oxygen from the air, gastrointestinal function organizes to take in and absorb nutrients, and her liver begins to metabolize in new ways. Other than the above-mentioned studies in asthma and perhaps a small number of studies in type 1 diabetes (as shall be discussed in Chapter 5), the effects of perinatal events are not known to have been studied in relation to specific physical diseases. Evidence from research studies is increasingly supportive of the concept that environmental factors, even in the prenatal and perinatal time frame, can play an important role in the origins of chronic illness.

Conclusion to the Literature Review

A number of themes have appeared in the preceding sections regarding the influence of environmental factors on the development and regulatory capacity of the nervous system. These themes include evidence that

1) events influence structures during certain periods of their development;
2) the bond between adult and child is important to survival, attachment, and health, and influences the ability of the nervous system to respond to stress throughout life;
3) high states of arousal are stored in memory even in prenatal life;
4) memories of events associated with high states of arousal are probably never truly extinguished and can be reinstated by future experiences of stress;
5) organisms attempt to adapt to experiences too overwhelming to autoregulate by reverting to progressively older (more primitive) evolutionary defensive strategies;
6) when the immobility/freeze response is utilized and remains undischarged, maladaptive behaviors eventually result; (see article on Trauma)
7) the impact of life experiences can be transmitted across generations.

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