Environmental factors affecting the nervous system and health:
The role of early relationships

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Chapter 2: *Literature Review: Attachment*

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Abstract

Gene-environment interactions play an important and as yet rarely recognized role in contributing to our long-term *physical* as well as emotional and behavioral health. Early relationships shape our developing nervous systems and are increasingly understood to influence our risk for physical symptoms and disease. Since the nervous system is intimately involved in the regulation of a large number of (if not all) physiological activities in the body, the process by which it learns to self-regulate plays an important role in our long-term *physiological* rhythms as well as in our behavioral and emotional patterns.

This article is based primarily on the neurodevelopmental research of Allan Schore, Ph.D. It explains the role of the bond between caregiver and child during the first months and years of life, a period referred to in the psychological literature as the period of *attachment*. During attachment, the nervous system is shaped by gene-environment interactions in the process of *experience-dependent maturation of the nervous system*. This developmental process trains our nervous systems to competently and easily change from states of arousal to states of inactive alertness and rest, and back again. By learning how to tolerate states of high arousal or immobility, and by gaining the capacity to inhibit certain states such as the stress response, experience-dependent maturation facilitates the capacity for enhanced autonomic self-regulation. This article describes the four stages of the attachment period, during which synapse formation, selection, and strengthening is understood to be shaped by both genetics and the environment of parent-child interactions.

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The Role of Attachment

The Role of Attachment in the Development of the Nervous System

Introduction

Attachment consists of a period beginning 2 months after birth and lasting until approximately 3 years of age. The founder of attachment theory, John Bowlby (1969, as cited in Maunder, 2001), explained that this drive for attachment serves a survival function through the recruitment of protection from adults and the social group, but also promotes the development of the nervous system to enable the infant to learn how to manage his or her own internal physiological processes.

> Before the emergence of organized attachment behavior (i.e., before learning) infant signaling of needs is innate and responsive to immediate stimuli. In this … period appropriate proximity relies on parental anticipation of infant needs and sensitivity to infant signals. Thus, the same processes of mutual engagement and interaction that initially serve to maintain proximity as an end in itself are the crucial prerequisites of both emotional attachment security and *physiological self-regulation. These intertwined developmental processes ultimately result in an organism that can independently maintain homeostasis and mount a physiological response to external threat* [italics added]" (Bowlby, 1969, as cited in Maunder p 558).

The manner in which the developing nervous system is intimately influenced by the environment of the attachment bond with the caregiver is described in great detail by Allan N. Schore, a psychoanalyst in the Department of Psychiatry and Biobehavioral Sciences at the University of California at Los Angeles, School of Medicine. Unless otherwise stated, this section on attachment refers entirely to the ideas presented by Schore in his book "*Affect Regulation and the Origin of the Self: The Neurobiology of Emotional Development*" (1994). Page numbers are provided for salient points to enable the interested reader to examine key areas in more depth.

In his work, Schore examines the psychological developmental stages described in the psychoanalytic and object relations literature and correlates behavior with specific brain structures known to develop during each of the psychological stages. The resulting developmental neuroscientific theory integrates research from over 2500 studies in a number of fields to provide a detailed explanation of the socioemotional factors that influence the physiology, endocrinology, and psychological processes associated with the experience-dependent maturation of the nervous system (Schore, 1994). Schore describes the role of the primary caregiver as being the key environmental factor involved in shaping the infant's developing nervous system stating that, "for the developing infant, the mother *is* the environment" (1994, p. 78).

"Increasingly complex self-regulatory structural systems mature during infancy, and their development is a product of early dynamic object relational environmental interactions that shape the outcome of genetic predispositions"(Schore, 1994, p. 34). In a fascinating evolutionary adaptation that enables increased plasticity and flexibility in the human brain, infants are extremely vulnerable at birth and in early life. The infant therefore needs an external regulator, and this function is filled by the primary caregiver.

In Schore's (1994) detailed analysis of the development of the nervous system, it becomes evident that the interdependence between emotions and their physiological correlates provide the foundation on which the nervous system matures and develops its excitatory and inhibitory capacities for self-regulation. "Emotional expression is mediated by the energy-mobilizing sympathetic and energy-conserving parasympathetic components of the autonomic nervous system (Truex & Carpenter, 1964, as cited in Schore, 1994, p. 30), and these components continue to develop postnatally" (Schore, 1994, p. 30).

In this (1994) and other works (2001a; 2001b), Schore emphasizes how interactions influence the regulation of nervous system activities that determine secure and insecure styles of attachment expressed at physiological as well as psychological levels. These early experiences shape the short and long-term *physiological* capacities of the nervous system that are involved in coping with stress. The physiological responses to stress involve varying levels of sympathetic (SNS[1]) and parasympathetic nervous system (PNS) activity, as well as autonomic (ANS) and central nervous system (CNS) regulation and inhibition.

This information provides a foundation for understanding ways in which stimuli are integrated by the brain to formulate responses to a particular environment. Early interactions influence these responses (Schore, 1994) in ways that maximize, or interfere with, the capacity of the organism to engage in the more energy-efficient recent evolutionary strategies of nervous system responses to threat (2001). The capacity of the organism to fluidly move between a range of attachment and defensive strategies as its environment changes is relevant to the origins of disease (1994). This section seeks to present sufficient detail concerning the manner in which the nervous system is affected during development to enable the reader to consider the role of attachment in early life as a possible source of risk for, as well as protection against, the development of disease such as diabetes, multiple sclerosis, and Parkinsons' as well as unusual symptoms such as globus, chronic pain, and nervous tics.

The Role of Attachment

The attachment process has a major influence on the growing nervous system, particularly during critical periods of intense growth and pruning in the first few years of life. The quality of the behavioral and physiological interactions between infant and mother is related to the degree to which they bond[2]. This bond imprints the developing brain in such a way as to influence the individual's capacity for autonomous physiological as well as psychological self-regulation. It helps an infant regulate basic metabolic processes such as body temperature and digestion, and gradually facilitates the learning of patterns of CNS, SNS and PNS communication, dominance, and regulatory capacity. These patterns of nervous system regulation generally last into adulthood.

Schore (1994) describes the manner in which an infant progresses from physiological stages of total dependence on the mother during the psychological developmental stage of symbiosis, to the capacity to self-regulate at a physiological level during the separation/individuation phase. The following overview briefly summarizes these stages and is followed by a detailed description of each stage (see Table 2-6). This section is not exhaustive although the degree of detail presented sets the stage for a clear understanding of environment-brain interactions that influence differences in individual responses to stress. Stress is thought to play a role in the development of many chronic illnesses as well as in day-to-day variation in symptoms.

Brief Overview of the Developmental Neurophysiology of Brain Growth

I. The attachment period begins at approximately 8 weeks, when genetically programmed synapse formation reaches a particular phase in the development of the visual cortex. Following this period, mother-infant gaze transactions intensify. During the early symbiotic period occurring ***between 2 and 8 months of age***, these gaze transactions specifically foster growth of SNS circuits *from* the subcortex *to* centers in the maturing frontal cortex, which have greater hierarchical regulatory capacity.

II. The next phase begins ***at 10-12 months*** as growth in the frontal cortex promotes

[1] ANS: Autonomic Nervous System; PNS: Parasympathetic Nervous System; SNS: Sympathetic Nervous System; CNS: Central Nervous system

[2] The mother is generally referred to by Schore and other authors as being the primary caregiver.

locomotion and upright stance, which enables the infant to engage or disengage more actively with his environment (Schore, 1994, p.93). This phase of increased mobility, described as the practicing period in developmental psychoanalytic terms, is associated with high sympathetic arousal and a corresponding emotional tone of elation in which the infant seems impervious to failure. This early part of the practicing phase is specifically associated with development of the prefrontal cortex, and its more dominant right side. Nervous system development at this time is predominantly mediated by sympathetic *hyper*arousal, which promotes elation, interest, and exploration of the environment. Such mobilization activities mature early because the activities and energy levels they foster literally promote the growth of an abundance of nerves and nerve connections.

III. ***At 16-18 months*** the toddler enters the late practicing phase. During this time, anatomical development in brain growth is associated with the beginning of inhibitory behavior as the mother (unconsciously) begins to socialize her child by prohibiting certain activities now deemed unacceptable. These "socializing" activities curb the state of high sympathetic arousal to promote the development of important energy-conserving states of moderate arousal. These interactions enable the cortex to inhibit states of high SNS arousal and to grow the capacity for PNS circuits that foster levels of moderate arousal. These activities also enable the nervous system to learn to transition from one state of arousal to another, a skill vital to adaptation and the maintenance of homeostasis.

During this late practicing phase, nerve circuits begin to grow downward from the cortex to the subcortical structures of the ANS. These circuits are inhibitory in nature, and are parasympathetic. In this stage, the toddler is no longer impervious or elated. Instead, he is quite sensitive to his mother's inhibiting behavior and easily experiences "shame", which Schore (1994) describes as the state that shuts off SNS activity. The physiological state of low PNS arousal is related to the immobility/freeze response.

The quality of the reunions following the shame-inducing interactions facilitates a transition to a new state of arousal. This new arousal state is a PNS mediated moderate level of energy associated with inactive alertness. Inactive alertness is optimal for learning, restoration, and integrative functions and occurs as a result of the capacity to inhibit impulsive behavior. The experiences associated with moderate arousal influence the selective pruning of nerves and nerve connections and inhibitory function therefore matures later than growth-promoting states of hyperarousal. By the middle of the second year, maternal-infant transactions have increased the infant's capacity to self-regulate, and he is able to transition from SNS dominance to PNS dominant states and back again in response to external and internal cues even when he is not in the presence of his caregiver (Schore, 1994, p. 230).

IV. The end of the late practicing period marks a transition into the rapprochement phase, which is characterized by ambivalence towards the mother and takes place from ***15 to 18 months*** of age. During this time, the father plays an increasing role in arousal modulation that influences the development of the left cerebral cortex, which is "the last area of the brain to attain functional maturation" (Schore, 1994, p. 234). This part of the brain interacts with the right hemisphere to facilitate ANS regulation and continues to develop at least until adolescence (Diamond, 1990, Huttenlocher 1982, and Thatcher 1991, as cited in Schore, 1994).

The Development of the Nervous System

The immaturity of the nervous system at birth allows it to be shaped by its environment, which facilitates its capacity to adapt to its own unique circumstances (Siegel, 1999). The human brain undergoes dramatic growth beginning in approximately the third month of pregnancy and continuing until 18-to-24 months of age (Allan N. Schore, 2001b). As has been mentioned, the primary processes that

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drive brain growth are genetic and environmental. The process of brain growth consists of the development of nerves and an overabundance of synapses and connections which are then shaped, selected, and pruned as a result of genetically programmed timing (Bruer, 1998) as well as by interaction with the environment (Kotulak, 1998; NCRIM, 2000; A. N. Schore, 1994; Siegel, 1999). The process during which environmental factors influence the genetically timed development of the nervous system is referred to as experience-dependent maturation.

The experience-dependent maturation of the brain occurs primarily through the social and emotional context of interactions with the primary caregiver, in which affect regulates brain growth (Trevarthen, 1989, as cited in Schore, 1994, p. 78).

Although the caregiver's role in nervous system development is central, it is not the sole environmental contributor. Factors outside of a caregiver's control, including his or her own childhood experiences and the cultural environment in which these have occurred, also shape the manner in which interactions occur between parent and child (Brazelton & Cramer, 1990; Klaus & Kennell, 1976; A. N. Schore, 1994).

In addition, prenatal and perinatal events influence [3] shape the manner in which parents and infants are able to bond with one other, an event that greatly affects their ability to attune during attachment (Klaus & Kennell, 1976). Prenatal and perinatal events also shape the nervous system and influence its capacity to respond to stress, including the stress that occurs in interactions during the attachment period and beyond (Klaus & Kennell, 1976). Finally, these prenatal and perinatal events may also influence the *infant* in ways that can evoke particular styles of attachment behavior from caregivers and that contribute to the unique style of interaction that occurs between a parent and child (NRCIM, 2000). For example, an infant who has experienced a disruption in bonding may cry more frequently. Instead of eliciting increased caretaking behaviors, however, this expression of distress may overwhelm a similarly poorly bonded mother and result in distancing and dissociation.

The Four Periods of Attachment

I. Symbiosis, Gaze Transactions, and the Developing ANS

While infants and mothers gaze at each other from birth (Klaus & Kennell, 1976), fixation on the mother's eyes increases after the second month (Maurer & Salapatke, 1976, as cited in Schore, 1994, p. 72), during the symbiotic phase of "pronounced dependency" (Corey, 2001). This shift in the importance of gaze transactions occurs following a growth spurt of the visual cortex during the weeks that precede the onset of this period. Gaze transactions influence the infant's growing nervous system through imprinting (Schore, 1994, p. 75), a process by which the "heightened energy in the new parent and small baby … leads them to attach to and learn about each other" (Brazelton & Cramer, 1990).

The visual perception of facial expressions has been shown to be the most salient channel of nonverbal communication (Izard, 1971, as cited in Schore, 1994), and visual modes of communication that precede vocal modes of mutual communication (Schaffer 1984, as cited in Schore, 1994) are dominant in the forging of preverbal affective ties in the first year of life (Schore, 1994, p. 72).

Gaze interactions as mediators of nervous system growth.

The process of imprinting specifically affects the earlier maturing right hemisphere of the brain (Schore, 1994, p.76), which is dominant for gaze behavior (Meador et al., 1989, as cited in Schore, 1994, p. 75). This hemisphere is also specialized for attending to facial emotion (Etcoff, 1983a, as cited in Schore, 1994), and controls the ANS and endocrine systems involved in emotional functions (Schore, 1994, p. 59). The manner in which caregivers modulate gaze transactions

[3] see Thesis Section / Article on Prenatal and Perinatal Factors, which can be downloaded from http://veroniquemead.com/library.php

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directly affects nervous system development. These experiences affect the infant's sympathetic nervous system by fostering his [4] capacity to tolerate increasing levels of arousal, and influence the development of his more slowly growing PNS through the manner in which he learns to recover from these periods.

This process of visual interaction is facilitated by naturally occurring events such as the fact that infants, who are able to focus most clearly on objects 10 inches away (Haynes, White, & Held, 1965, as cited in Schore, 1994), tend to be held by mothers at this distance (Papousek & Papousek, 1979, as cited in Schore, 1994). This is also the distance between the face of mother and infant during breastfeeding, when she cradles her infant in her arms.

Interactive states are intensely pleasurable to infants (Stern, 2000) as well as to their caregivers (Schore, 1994), and represent a process by which inherent biological mechanisms stimulate or drive attachment behaviors. During periods of mutual gaze between mother and infant, "the emotional expressions of one member of the mother-infant … relationship tend to elicit emotions in the other" (Termine & Izard, 1988, as cited in Schore, 1994, p. 80). Attuned mothers stimulate their infants to increasing levels of arousal through natural, unconscious behaviors that are particularly evoked by the eyes.

"The sight of her infant is physiologically arousing to the mother" (Wiesenfeld & Klorman, 1978, as cited in Schore, 1994) and mothers' eyes dilate when they see their infants. Experimenters with dilated eyes evoke more smiles in infants, and dilatation in infants' pupils releases caregiver behavior. In addition, pupil dilatation in one individual evokes dilatation in another's (Hess, 1965, as cited in Schore, 1994).

Pupil dilatation is regulated by hypothalamic centers that regulate the SNS (Truex & Carpenter 1964, as cited in Schore, 1994) and occurs with states of interest (Schore, 1994, p.73), as well as in the arousal of fight/flight (Ganong, 2001). The type of pupil dilatation involved in maternal-child interactions appears to be different from that of fight/flight, however. In attachment interactions, pupil dilatation is described as coming from "a state of alert inactivity in which the eyes are open and have a 'bright shiny appearance'" (Demos, 1988, as cited in Schore, 1994, p. 73) and corresponds to a similar state in the infant (Brazelton & Cramer, 1990). This is also supported in research by Tronick, Ricks, & Cohn, (1982, as cited in Schore, 1994), who find that infants exposed to mothers with no 'brightness' in their eyes express negative states. This author (V Mead) speculates as to whether the gaze and facial interactions of early life relate to activity of the parasympathetic aspects of the social engagement system mediated by the VVC [5] (Porges, 2001), or in instead by a process of vagal withdrawal that facilitates SNS activity in an energy-conserving manner. Insufficient information is available to pursue this exploration at this time.

Gaze interactions and sympathetic nervous system development.

Prolonged gaze is "the most intense form of interpersonal communication" (Tomkins, 1963, as cited in Schore, 1994, p. 72) and instigates high levels of arousal in both participants. This high level of arousal is facilitated by dopamine and opioids in the reward centers of the brain (Schore, 1994, p. 91). Dopamine is a SNS catecholamine whose effect differs from norepinephrine-mediated states of arousal such as fight/flight in that it is associated with pleasure and reward systems. The dopamine system connects subcortical areas of the SNS to the cortex, and more specifically, to the right hemisphere. While this growth occurs as part of the genetically programmed development that is associated with this period of infant development, the high arousal in gaze transactions facilitates brain growth by influencing the density and strength of the connections. The specific dopamine pathway by which the lower or

[4] the use of masculine and feminine pronouns is varied throughout this document

[5] ventral vagal complex of the social engagement system as described by Porges

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subcortical parts of the brain connect with the cortex is called the "ventral tegmental" dopamine circuit (Schore, 1994, p. 83).

This ventral tegmental circuit extends to the orbitofrontal cortex, which is an area in the front of the brain that is located above and behind the eye. This functional designation is divided into two areas, the early maturing orbitofrontal cortex and the later maturing dorsolateral cortex (see figure 2-8 on the next page). The orbitofrontal cortex is responsible for the regulation of socioemotional functioning and therefore mediates relevant ANS functions, such as relational interactions and arousal states such as fight/flight.

Gaze interactions and parasympathetic nervous system development.

Another factor involved in gaze transactions and nervous system development is associated with PNS function, which cycles with SNS activity to support optimal levels of arousal in the infant. These cycles are brief, often lasting only seconds, but are measurable in microanalysis of frame-by-frame video observations in studies cited by Brazelton & Cramer (1990), Stern (2000), and Schore (1994).

When an infant reaches her tolerance of stimulation she "gaze averts to self-regulate emotional arousal and … reduces her input so as to provide an optimal level of arousal (Brazelton and Cramer, 1990, p. 105). Psychobiologically, gaze aversion is a 'cut-off' arousal reducing mechanism (Chance, 1962, as cited in Schore, 1994, p.85) which *discharges* an overload of social information processing" ([italics added] Schore, 1994, p. 85). Schore does not expand on the process by which a system "discharges" although the term is described in somatic psychology as a function by which the nervous system physically releases a high energy state (Caldwell, 2001).

The discharging activity may consist of tiny movements such as gaze aversion with or without head turn. Discharge behavior can range from the large muscular activity of fight/flight to subtle invisible processes (Caldwell, 2001) that might occur as a result of physiological activity. [6]

PNS development, which occurs during gaze transactions, relates to the degree of bonding and attunement between mother and child (Schore, 1994). The more attuned a mother is to her infant, the more she responds to gaze aversion by modulating her own behavior to foster the delivery of appropriate amounts of information that can be processed by the infant's developing right hemisphere (Schore, 1994, p.87).

The more the mother "tunes" her activity level to the infant during periods of social engagement, and the more she allows him to recover quietly in periods of disengagement, the more synchronized their interaction (Penman, Meares, and Milgrom-Friedman, 1983, p. 1, as cited in Schore, 1994, p. 86).

The decrease in maternal stimulation in an attuned dyad allows the infant to recuperate in a state of moderate rather than elevated or depressed arousal. When ready, the infant initiates eye contact as a signal that she is ready for more stimulation. By facilitating these transactions, the mother acts as an external regulator (Schore, 1994, p. 87) or "auxiliary cortex" (Hofer, 1984, as cited in Schore, 1994) for her developing infant. Consistent experience of this type of arousal modulation enables the infant to learn that she can engage according to her own state of

[6] The process by which discharge occurs is an interesting one in that it appears to consist of a means by which organisms integrate and metabolize information. Based on the discussion presented above, physical and physiological discharge and integration appear to be the means by which the ANS transitions from states of high to low arousal. This is an interesting issue to consider because the capacity of the nervous system to transition between states of arousal is important to the ability of an organism to adapt, and hence, may affect risk for disease.

From this perspective, the physiological process by which glucose is removed from the bloodstream through the actions of fighting or fleeing may also represent a form of discharge. One hypothesis of this thesis is that lack of discharge may eventually become visible as type 1 diabetes. This concept is discussed in Chapter 3.

readiness.

In disorganized or less optimal attunement interactions, a mother may continue to talk to and stimulate her child after gaze aversion, resulting in further stimulation of an infant that has already reached her tolerance level.

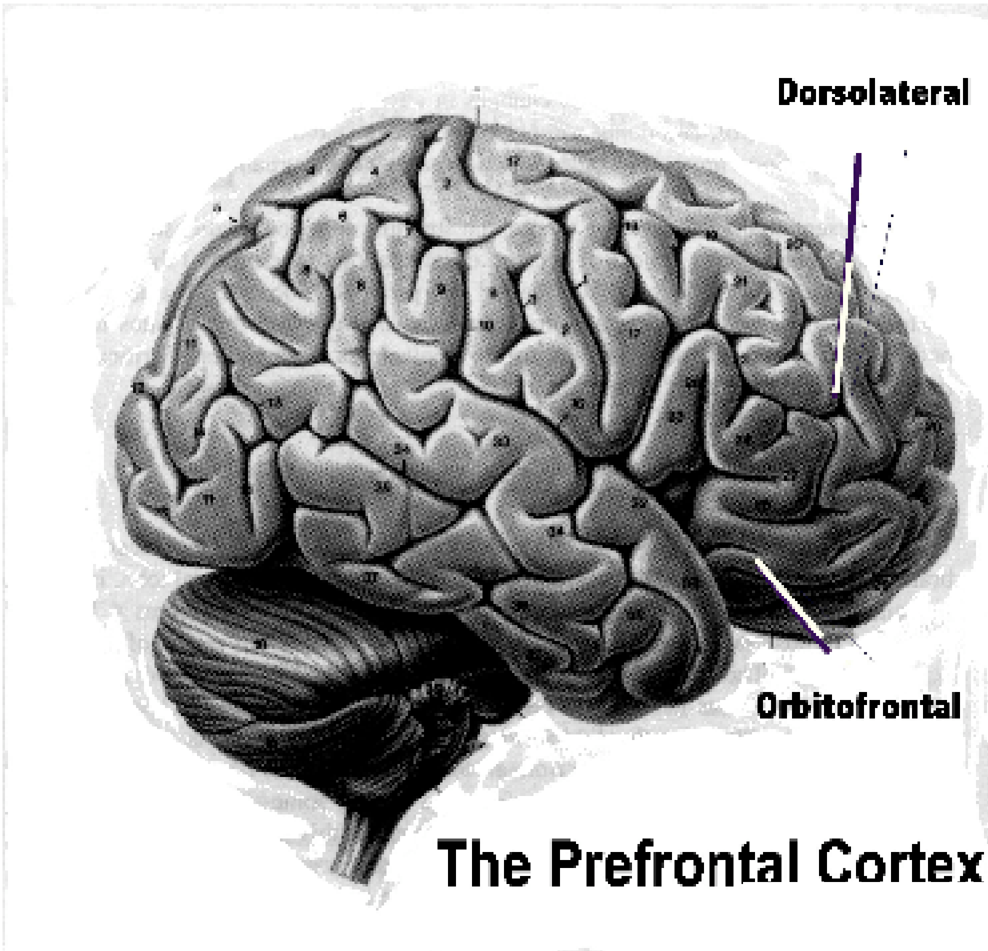

Figure 2-8. The Prefrontal Cortex.
Image adapted from "The prefrontal cortex" in *Affect Regulation and the Origin of the Self: The Neurobiology of Emotional Development* (Schore, 1994, p. 36).

Infant responses to this consequent overload are expressed as increased PNS arousal and are associated with distress generally expressed through crying. In somatic psychology theory (Caldwell, 2001), crying can be considered another form of discharge, and one that could be considered more energetically demanding than quiet gaze aversion.

There are less than optimal consequences of misattunement for the developing PNS. When a caregiver consistently and repeatedly misses gaze aversion cues and continues to provide stimulation, the infant does not experience the opportunity to quietly recover, and consequently, neither does her PNS (Schore, 1994). Furthermore, the infant learns that her signals telling her environment that she has had enough are not effective. In the long-term, this experience affects the manner in which this individual behaves in future interactions and if persistent, becomes incorporated into preverbal memory and in the way she perceives her environment (Schore, 1994). She may learn, at a physiological level, that her interpretation of having had enough stimulation is "incorrect". She may also develop difficulty in her capacity to self-soothe, which is a part of the self-regulating process of regenerative periods that occur in quiet states (Schore, 1994). If these overwhelming experiences are sufficiently frequent or intense, the infant may learn to discharge the intolerable levels of arousal through dissociative behaviors in an attempt to self-soothe (2001). Such behaviors may become patterns of dissociation that last into adulthood. These are consistent with displacement behaviors, which Caldwell refers to as "movement tags" (2001).

Caldwell refers to movement tags as a form of somatic addiction, an addiction to certain body habits used in an ineffective attempt to discharge intolerable states through movement (2001). She defines a tag in the following way:

> A tag is a small movement or gesture done anywhere in the body that distracted a person from the movement sequence they had been developing. In order for a movement to qualify as a tag, it had to exhibit all five of the following features: 1) it repeats, … often to the point of exhaustion, 2) it doesn't develop – the movement never goes anywhere … never progresses, 3) it doesn't complete – it never feels finished, never comes to a relaxed conclusion, 4) it doesn't satisfy – it may feel familiar and comfortable, even initially soothing, but the more you do it the less soothing it feels …. 5) it's difficult to watch [because] we feel disturbed in the presence of someone dissociating (p. 8).

Dissociative patterns of discharge may last into adulthood and affect the capacity for physiological transitions between states of arousal (Caldwell, 2001; A. N. Schore, 1994). An infant consistently exposed to overwhelming levels of stimulation may learn to discharge intolerable levels of arousal through patterns of less efficient, more energy-demanding behaviors. Such behaviors may, according to the hypotheses presented in this thesis, be expressed as chronic illness and physical symptoms, representing physiological "movement tags".

The role of misattunement in mediating tolerance for increased levels of arousal.

Periods of misattunement are common between caregiver and child, and serve an important function. The manner in which the mother instigates as well as "repairs" misattuned transactions influences the growing nervous system. If she ignores gaze aversions or overstimulates her infant, arousal states too overwhelming for the infant to regulate on her own can ensue.

The effects of misattunement are particularly influenced by the manner in which a mother reattunes following a period of overwhelming stimulus. If a mother recognizes this and has the capacity to reattune, the infant gradually learns that the possibility of repair exists. The experience of brief and slight overwhelm during misattuned interactions generates a greater capacity in the infant to tolerate undischarged SNS arousal, and fosters the growth of a more robust SNS. "An essential function of the mother is to permit the child to bear increasingly intense affective tension, but then to step in and comfort the child before his emotions overwhelm him" (Krystal, 1978, as cited in Schore, 1994). " The mother's prevailing tendency to overshoot, just by a little, her infant's tolerance boundaries induces the infant to stretch and grow" (McLaughlin, 1989, as cited in Schore, 1994, p. 89).

> 'In the "symbiotic" state, the adult's and infant's individual homeostatic mechanisms are linked together in a superordinate organization which allows for 'mutual regulation of vital endocrine, autonomic, and central nervous systems of both mother and infant by elements of their interaction with each other' [Hofer, 1990, p. 71]' …. Indeed, … [Hofer, (1984a)] provides evidence to show that the mother is *the* regulator of the functioning of the infant's developing autonomic nervous system (Schore, 1994, p.78).

The child's increasing ability to tolerate emotional intensity is visible during this period, and is correlated physiologically with

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changes in heart rate (Schore, 1994). At the age of 3 months, infants' heart rates decrease with smiling and by 9 months, babies show heart-rate acceleration during smiling (Emde, Campos, Reich, & Gaensbauer, 1978, as cited in Schore, 1994, p. 89). Schore's point is that this represents an augmented capacity to tolerate the high SNS arousal states that occur in the increasingly intense and joyful attachment interactions, and is associated with development of the SNS. The capacity to tolerate high levels of arousal influences the infant's ability to regulate the high levels of intensely positive affect that are the hallmark of the early practicing phase known as separation/individuation, which follows symbiosis.

II. The Early Practicing Period: Active Arousal and Sympathetic Growth

The onset of the early practicing period begins at the end of the first year. It is defined by changes in locomotion and mobility as the infant enters the vertical plane and begins to walk, and is also described in object relations terms as the phase of separation/individuation (Mahler, 1980, as cited in Schore, 1994). This time period is particularly associated with the formation of an *enduring* attachment bond, which fosters nervous system growth and shapes the manner in which this individual will respond to his or her socioemotional environment.

Schore (1994) considers the affective qualities of this stage to be the most unique and definitional, saying, "mobile infants show different types of emotional reactions than prelocomotor infants" (Bertenthal, Campos, and Barrett, 1983, as cited in Schore, 1994, p 93). These dramatic affective transformations are critical to the establishment of permanent characteristics of the emerging personality. Perhaps more than any other time in the lifespan, the individual's internal state is externally observable and susceptible to socioenvironmental influences (Schore, 1994, p. 93).

This period is characterized by high levels of arousal, elevated activity level, and an emotional tone of elation, all of which are associated with an increase in sympathetic activity (Schore, 1994). These qualities, which define active infant play, fulfill an evolutionarily adaptive function for learning and stimulation that foster the growth of nerves and brain structure (Schore, 1994). The degree to which the infant experiences motivation, interest, and elation are dependent on the level to which he has learned to tolerate states of arousal during the previous symbiotic phase. ANS growth in the preceding period, particularly sympathetic development, is important to the ability of the sympathetic to foster behaviors that support brain growth in this phase.

In concordance with his overall theory, Schore (1994) explains that the structures that are developing during this time are influenced by genetic factors that affect behavior (by fostering high activity levels and elation during this time period, for example). These behaviors, and the interactions that occur with caregivers as a result, in turn influence the maturation of these brain structures. Excitement and interest foster stimulation-seeking behaviors that promote the exploration of the newly available nonmaternal environment, and are specifically associated with the development of connections that link the ANS structures, such as the hypothalamus, with the higher structures of the cortex. These connections form as a result of an expansion of the ventral tegmental dopamine circuit as it connects upward to the orbitofrontal region of the right prefrontal cortex.

The orbitofrontal cortex is particularly important in the ability to assess one's environment, and perception determines how an individual responds. The early part of the practicing period imprints this system in a way that "for the rest of the lifespan appraises the affective and motivational significance of environmental stimuli" (Schore, 1994, p. 113). The relationship dynamics between caregiver and infant during this time therefore have a particular impact on the manner in which structures and connections mature that influence the *perceptions* of the growing infant.

The Caregiver as a "Secure Base" and an Indicator of Safety.

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During this period of infant curiosity and exploration, the mother continues to serve as a psychobiological regulator (Taylor, 1987, as cited in Schore, 1994, p. 26). She helps her infant transition into optimal levels of arousal by energizing him at appropriate times when he is in low energy states, as well as by modulating or "down-regulating" when he is in nonoptimal high levels of arousal (Schore, 1994, p. 107). As the infant now moves between his new environment and his mother he begins to learn to self-regulate, which now occurs when he is "alone" yet still in her presence.

The infant is motivated to leave the presence of his mother by his sympathetically generated curiosity, interest and high energy levels, and is capable of leaving because she represents a locus of safety. The safety function of the attachment bond thus provides "a 'secure base' from which the mobile toddler may sortie to explore the world and then return in the face of physiological need or danger" (Bowlby, 1988a, as cited in Schore, 1994, p. 102). In this context, the infant, who is "increasingly sensitive to her gaze, keeps an eye on the feelings expressed on the mother's face. The child thereby uses the mother's affective expressions as a signal, an indicator of her appraisal of danger or safety in a particular environmental circumstance" (Oakley & Jenkins, 1992, as cited in Schore, 1994, p. 102).

The mother's facial expressions, including those that are highly transient and invisible to conscious awareness, transmit information to her child. The child's ability to interpret this meaning is therefore vital to his survival from an evolutionary perspective. The capacity for appraisal of the environment is highly tuned to facial expression, and is specifically facilitated by the developing right orbitofrontal cortex. Because infant states of high arousal and interest facilitate brain and structural growth, maternal behaviors that affect the capacity to experience these states also influence this phase of brain development (Schore, 1994, p. 102).

Interactions and alternating sympathetic parasympathetic dominance.

During the period that the child is away from his mother, sympathetically driven exploration and locomotion enable him to explore the environment under his own volition. These periods of sympathetic arousal are interspersed by states of parasympathetic arousal and are followed by a return to states of sympathetic activity through reunion transactions with the mother. Although interactions during this period are predominantly mediated by sympathetic arousal, they also support oscillation in nervous system balance.

> The mother, through her entrained interactions, directly influences the developing rhythmic pattern of the child's activity-passivity cycles. In this manner the primary caregiver's unique patterns of psychobiological attunement, misattunement, and reattunement effect the creation of cycles of social engagement and disengagement in the infant... The mother's rhythmic responsiveness regulates the autonomic, behavioral, neurochemical, and hormonal functions of the infant" (Anders and Zeanah, 1984, as cited in Schore, 1994, p. 107).

States of low energy following exploratory behavior are visible in the tired child who has limp arms and drooping face, and who is in a state of parasympathetic dominance. Schore once again describes the transition into this state as occurring through "discharge". This discharge seems to mark the transition from states of sympathetic dominance to parasympathetic dominance and the term has been described in an earlier section with respect to the regulatory function of gaze aversion.

When the child is in the low energy state following sorties, he is also in a state of parasympathetic receptivity in which he can be influenced by interaction with his mother, who can increase his arousal and reenergize him to explore. This transition from parasympathetic to sympathetic dominance occurs during reunion episodes, and may occur at a distance through visual cues, or through proximity and/or contact. During reunions, mothers read

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their infants' faces to appraise their internal states and adjust their output to provide the optimal level of response or stimulus (Schore, 1994, p. 103). This maternal capacity occurs at an unconscious level, and is most developed in dyads that are "biologically attuned" (Schore, 1994).

In psychobiological attunement, "the language of mother and infant consists of signals produced by the autonomic, involuntary nervous system in both partners " (Basch, 1976, as cited in Schore, 1994, p. 105). Maternal regulation of the behavioral and ANS states of the infant occurs at a nonverbal level, and is primarily regulated by the maturing right prefrontal cortex. The right prefrontal cortex is also influenced by these transactions.

The manner by which the mother is able to reenergize her infant is increasingly understood in the scientific community (Schore, 1994). As described earlier, the attachment bond is pleasurable, and during this developmental period pleasure is associated with sympathetic dopamine activity. During the energizing process that Mahler refers to as "refueling" (Mahler, 1980, as cited in Schore, 1994, p. 104), interactions with the mother result in increases in heart rate in her toddler. During reunion episodes, the mother serves as an "amplifier of positive arousal, and "acts as a generator of energy required for further physical exploration of the environment by the infant. This allows for ongoing separations and reconnections" (Schore, 1994, p. 102).

Characteristics of the maturing brain.

Characteristics of nervous system development relevant to this stage of infant development are presented below, including 1) the role of dopamine in brain growth, 2) the dominance of nervous system excitation over inhibition, and 3) the "internalization" of visual experiences. These processes help shape conditioned responses and the development of self-regulation during experience-dependent maturation.

Dopamine.

During the early practicing period, the dopamine circuit that connects the hypothalamus and other subcortical areas to the right (and not the left) orbitofrontal cortex matures. While a number of dopamine-mediated brain structures grow during this developmental period, research shows that in comparison with other structures, the development of the orbitofrontal structure requires social stimulation for optimal development (Holson, Ali, and Scallet, 1988, as cited in Schore, 1994, p. 131). During the early part of the practicing period, pleasurable qualities of social interaction, which are important to SNS fostered nervous system growth, are mediated and intensified by dopamine. During the formation of the enduring attachment bond in this period, "amplified [high] levels of arousal act as a signal for the imprinting of new circuits in the orbitofrontal cortex" (Schore, 1994, p. 134). Dopamine supports nervous system growth by increasing availability of fuel to the developing tissues. This fuel is glucose, and dopamine makes it available by "degrading glycogen to glucose and … converting glucose to [specific types of] sugars (Schore, 1994, p. 134).

Excitation versus Inhibition.

The characteristic high arousal of this period represents an imbalance in total brain functioning in which excitation is more predominant than inhibition. Dopamine plays a role in that it mediates general arousal that "produces energy-expending increased excitability of the orbitofrontal cortex" (Schore, 1994, p. 134).

Internalized Images

The developing right orbitofrontal cortex has many different functions, including a capacity to regulate the ANS through a very direct one-synapse connection to the hypothalamus (Schore, 1994). This part of the brain also controls arousal and aggression in addition to homeostasis. Connections between the visual cortex and the orbitofrontal cortex that form during this period allow the developing right frontal brain to receive, appraise, and respond to cues coming from both the external and the internal environment.

As a result of repeated exposure to experiences of the caregivers' behavioral, physiologic, and emotional responses, which are expressed through facial gestures, visual images that correlate with these experiences become "internalized" in the infant through the

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process of conditioned procedural memory" (Scaer, 2001a; Schore, 1994). These visual snapshots become "flashbulb memories" and are recalled unconsciously when similar situations recur throughout life, including at times when the mother is not present. The capacity to form memories and to evoke responses to previous experiences serves the function of enabling the infant to develop the capacity to self-regulate behavior.

The process of internalization results in adaptive (or maladaptive) conditioned responses in the infant that are affected by internal cues, such as sensations coming from his own physiology, and external cues, such as the experience of seeing people's emotionally expressive faces.

The internalization of images of psychobiologically regulating others, as well as other types of experiences, is a memory that serves an affect regulating function. When a child or adult encounters a new person, for example, the imprinted flashbulb memory is accessed as a reference from which to interpret the meaning of the newcomer's facial expressions, and guides the response and associated activation levels. The accessed memory is the internalized visual image of his mother's face and gestures, organized through his unique experience of her. This process also occurs with respect to inanimate objects. If a child comes up to a burning fire in the fireplace, for example, the recollection of his mother's misattuning facial gesture that once conveyed a message of "NO!" is accessed and provides the internal cue that fosters the self-regulatory action of impulse inhibition.

> In the further course of development, repeated experiences of separation and reunion are remembered and anticipated, providing the structural basis for progressively more varied and modulated affective responses, whether basically painful or basically pleasurable (Pao, 1971, p. 788, as cited in Schore, 1994, p. 103).

III. The Late Practicing Period: Shame, Passive Arousal, and Parasympathetic Growth

The late practicing period consists of a transition away from positive emotional states towards more fearful states. This transition is influenced in part by maternal behavior, which changes from the high affection, play, and caregiving activities of the early practicing period to behavior associated with prohibition and socialization. The mother's behavior seems to occur in response to a child who now has a well developed sympathetic high arousal system that leads him to get into things and to seek to have his way despite knowing what his parents want (Schore, 1994, p. 200). These maternal expectations change in a way that now fosters the growth of inhibitory impulses as she demands that her child delay behavior that is eminently pleasurable. This maternal behavior fosters the child's capacity to curb impulse behavior and facilitates the development of the inhibitory parasympathetic system.

The transition from states of high arousal to low arousal and back again occur in this period, with an emphasis this time on the *low* arousal state. This activity helps establish two mature branches of the ANS and influences the capacity of the higher brain to regulate these functions. Orbitofrontal regulation is important since this area of the CNS can integrate information from outside as well as inside of the body to coordinate the most appropriate response. Following this stage, the infant develops the capacity for an efficient level of arousal called the "alert inactive" state, which consists of neither high nor low arousal and is associated with the capacity to maintain focused interest and attention. This author (V. Mead) hypothesizes that misattunement during this period, which involves frequent experiences of shame, transitions to states of parasympathetic dominance may play a role in chronic illness such as some forms of chronic fatigue, to name one example.

This late stage of the practicing period is generally known for its cognitive, social, and behavioral prohibitions. Schore, however, views the role of affective communication (rather than behavioral and cognitive activities) as the key to nervous system maturation. The affective interaction emphasized by (1994) is nonverbally communicated through maternal facial expressions that convey misattunement

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and foster what Schore (1994) classifies as "shame" in the child (Schore, 1994, p. 200). Active misattunement induces stress in the child, and results in a change from a sympathetic state of high arousal to one of parasympathetic low arousal. Misattunement stops the dopamine and opioid fostered growth of sympathetic hyperarousal in the orbitofrontal cortex and the resultant stress from the unfamiliar and unpleasant interaction leads to increased levels of cortisol. Cortisol fosters the growth of cholinergic parasympathetic nerve connections from the orbitofrontal cortex to the hypothalamus and other lower brain centers. This new nerve pathway enables higher cortical centers to inhibit the SNS.

Schore (1994) explains that the low arousal states evoked by shame transactions, which are then modulated by important reunion episodes with the mother, provide the optimal condition of stress and stimulation required for the maturation of the inhibitory functions of the cortex- parasympathetic connections. As a part of the continued programmed growth of the infant's nervous system, the mother's behavior changes as an unconscious and adaptive means of providing appropriate environments for her child.

Misattunement and shame-induced states of low arousal.

In this late practicing period, the child is no longer impervious to frustration and is instead quite sensitive to the inhibitory actions of his mother. Increased levels of adrenal cortisol production that occur as a result of programmed brain development appear to foster this change in infant affect, and the stress arising from the change in interaction dynamics influences further production of cortisol. "Stress is defined as a change or a threat of change demanding organismic adaptation" (Schneiderman & McCabe, 1985, as cited in Schore, 1994, p. 209) and can thus occur in response to a novel stimulus, even if it is a positive event such as a birthday party.

During this stage, toddlers have fairly mature sympathetic nervous systems and live in increasingly active states of high arousal. When seeking interaction with their mothers, they come to her in states of high arousal and excitement and expect to be greeted by satisfyingly positive states of high arousal and joy as they have in the past. During this period, however, the toddler is greeted with an unfamiliar and "different" mother, one who actively misattunes. This experience is unexpected and therefore stressful, and "the infant is ... propelled into an intensified low arousal state which he cannot yet autoregulate" (Schore, 1994, p. 203).

The shift in the infant from a state of active arousal to one of passive arousal is induced by an experience of what Schore (1994) terms "shame". Shame is evoked by the facial expressions used by the mother. Shame fosters the rapid transition from a preexisting high arousal positive hedonic state to a low arousal negative hedonic state ... and occurs only when the individual is experiencing interest-excitement or enjoyment-joy. This negative affect, a specific inhibition of ongoing positive affects, is thus the infant's immediate... physiological-emotional response to an interruption in the flow of an anticipated maternal regulatory ... function" (Schore, 1994, p. 203).

Misattunement therefore precipitates an imbalance in the regulation of affect, as it has in earlier periods. The child's experience of low arousal in this period, however, is associated with decreased tone in the face, neck, and body and is visible as a "motionless headhang, ... loss of social smile, [eye aversion], and the hallmark of shame, blushing (which is known to be absent in early infancy)" (Schore, 1994, p. 204). Schore's reference to the fact that blushing is absent in early infancy implies that the PNS is immature and incapable of this function at a younger age. This state of low arousal is associated with other parasympathetic qualities including decreased mobility and interest consistent with conservation-withdrawal.

The state of shame evokes a psychophysiological stress reaction that activates the HPA axis and results in elevations of cortisol. Schore (1994) describes HPA axis activity as being a *parasympathetic* function (Schore, 1994, p. 211) associated with the onset of vagal function and further maturation

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of the orbitofrontal cortex. Shame-induced cortisol deactivates the ventral tegmental dopamine system that fosters sympathetic growth and as a result, influences the growth of the parasympathetic lateral tegmental circuit (Schore, 1994, p. 214). The growth of this parasympathetic inhibitory system is evident during this period as heart rate and blood pressure begin to decrease (Schore, 1994, p. 205).

To summarize, the role of shame is considered to be adaptive in an active child who is at risk of potential harm due to his increased mobility and exploratory behavior. Rapid appraisal of his mother's facial cues serves a protective function in a child whose right orbitofrontal cortex has become highly sensitized to interpreting her nonverbal gestures, even at a distance (Schore, 1994, p. 205). Indeed, this process facilitates behaviors that will endure into adulthood as visual experiences become internalized. As a result of these stored visual messages, memories of the prohibiting mother recur when the child encounters particular types of events requiring him to regulate his impulsive behavior. These events might be an encounter with a hot stove, a stranger, or some other form of threat, as well as novelty. Internalized experiences from this period help regulate impulsive behavior by promoting the capacity to delay responses, which are an important function of the parasympathetic system.

The role of reunion episodes following misattunement.

As in earlier periods, reunion episodes are very important for the optimal flexibility of nervous system regulatory capacity, and the mother plays an important role. The goal of maternal prohibition behavior is to prevent the child from getting hurt, and is thus aimed at his behavior, not his whole persona. Clarification through nonverbal interaction that it is the behavior that is being prohibited is a part of the reunion function.

Following a stressful misattunement interaction, the child "attempts to rebound" and looks up to and reaches for solace from his mother. If the caregiver is sensitive, responsive, and emotionally approachable, especially if she initiates and reenters into arousal-inducing affect-regulating mutual gaze visuoaffective (as well as tactile and auditory affect modulating) transactions, the dyad is psychobiologically reattuned, the object relations link (attachment bond) is reconnected, the arousal deceleration is inhibited, and shame is metabolized and regulated. These events define what Izard (1991) calls a positive socialization of shame (Schore, 1994, p. 243).

This psychobiological process is fostered by the reappearance of the toddler's "familiar" mother, as well as by touch and laughter. These activities inhibit the toddler's pituitary-adrenal response to stress and reduce cortisol levels (Schore, 1994, p. 243), and can occur in as little as 10 seconds (Schore, 1994, p. 244). The reunion reignites the sympathetic system and fosters mobilization behavior. A difference in level of arousal occurs however, as the infant transitions from the SNS dominant state of hyperarousal, to the low arousal of parasympathetic dominance induced by shame, into a new state following reunions. This change in arousal proceeds from alert activity, to frozen inactivity, to a new blend consisting of alert *in*activity, and promotes resiliency of the nervous system and the organism's capacity to cope with stress. Resilience is learned and is not genetically encoded.

The caregiver's dual function in arousal reduction and induction facilitates the establishment of a moderate level of infant arousal, a state known to be associated with focused attention and positive affect" (Malmo, 1959, as cited in Schore, 1994, p. 245). "The process of reexperiencing positive affect following negative experience may teach a child that negativity can be endured and conquered" (Malatesta-Magai 1991, as cited in Schore, 1994, p. 218). "Demos (1991) characterizes infant resilience as the capacity of the child and the parent to transition from positive to negative back to positive affect" (as cited in Schore, 1994, p. 245).

Effects of optimal and dysregulated attunement.

The experience of optimal attachment

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bonds leads to the formation of secure attachment, and the internalization of expanded positive and minimized negative affective experiences. Consistent and effective regulation by another results in an adaptable individual who can flexibly navigate into and out of states of SNS and PNS arousal. This function fosters the capacity to self-regulate, which continues through life as a result of the incorporation of effective internalized models.

> Under the aegis of a caregiver who is sensitive and cooperative in [the] reparative process, the infant develops an internal representation of himself as effective, of his interactions as positive and reparable, and of the caregiver as reliable... Salient 'distress-relief sequences' initiated by an accessible mother facilitate a transition in the infant to a state of controlled arousal, quiet alertness, and responsiveness. This allows the infant to recover from negative affect states, ... and permits him to develop the capacity for anticipation of relief and a sense of his own efficacy .... [Internalized models from effective interactive experiences are] stored as a unitary 'interactive representation', allowing for the developmental transition of external to internal regulation via increasing levels of internalization .... Such representations can be accessed in the future in order to autoregulate shame states (Schore, 1994, p. 246-8).

Experiences of a "psychobiologically dysregulating mother," on the other hand, result in insecure attachments and an imbalance in nervous system regulatory capacity as well as in the capacity to self-regulate. "Without access to the mother's affect regulating function, the child remains stuck fast for long periods of time in a parasympathetic-dominant state of conservation-withdrawal" (Schore, 1994, p. 247). Humiliation is a particular state that induces intensely negative affect in the child and stimulates both sympathetic and parasympathetic arousal. Shame-humiliation is one particular combination that is always associated with child abuse (Schore, 1994). As a result of the inability to autoregulate in such states, the child experiences helplessness and hopelessness.

> In helplessness, the distressed person depends (unsuccessfully) on the environment for relief, and feels personally powerless to change matters ... the child who learns hopelessness comes to believe that the self is inadequate, that one's deficiencies are to blame for one's powerlessness, and that there is no hope that others will come to the rescue (Powles, 1992, p. 416, as cited in Schore, 1994, p. 247-248).

As a result of frequent or consistent experiences of this type of state, children grow up using behaviors that attempt to utilize external objects to support their incomplete capacity for self-regulation. These attempts, however, are just as unsuccessful as they were in childhood. This type of behavior is considered to be the result of insecure attachment in early life.

Attachment and Stress.

The role of the attachment bond in facilitating regulation in response to stress has significant implications for the capacity of the developing infant to cope with stressful events throughout his life. As a result of optimal reunion transactions in early life, an infant responds to future stress exposure with less cortisol output, and a more rapid return to baseline (Schore, 1994, p. 243). He is thus exposed to less intense levels and shorter periods of cortisol than his counterpart with insecure attachment. Increased facility in responding quickly and in energy efficient ways to stress is in large part due to the long-term effects of handling and contact early in life, including in the prenatal and early postpartum period. These early experiences influence the concentrations of cortisol receptors, known as glucocorticoid receptors, in the frontal cortex of animals. "Glucocorticoid-sensitive neurons are involved in terminating the adrenocortical stress response (Sapolsky, Krey, & McEwen, 1984, as cited in Schore, 1994, p. 243).

Optimal early experiences also result in

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the increased production of corticotropin releasing factor (CRF) in response to stress. High CRF levels increase exploratory behavior, and activate the SNS. Increased uptake of cortisol inhibits CRF expression, and represents the high cortisol parasympathetic state of low arousal seen during the shame-induced responses of the late practicing period. Cortisol and CRF levels thus play an important role in organismic response to stress and both are regulated by the orbitofrontal region. In fact, the orbitofrontal cortex overrides lower mechanisms of homeostasis regulation in times of stress (Schore, 1994, p. 225). This unconscious process is referred to as a "top-down" mechanism of arousal regulation (*Hakomi somatics: trauma training manual*, 2001). As a result, "the environmentally attuned prefrontal cortical system … can rapidly uncouple arousal and switch off sympathetic cardiac acceleration and switch on parasympathetic cardiac deceleration. In this way, this structure acts as a cortical system which regulates autonomic responses to affective [emotionally related] cues" (Schore, 1994, p. 225).

Summary: III.

The late practicing period occurs in an environment of increased cortisol related to a maturing parasympathetic system, and shame-induced experiences of stress further increase cortisol levels. High cortisol levels and the parasympathetic state of shame inactivate the previously dominant SNS and foster growth of the lateral tegmental circuit down from the maturing orbitofrontal cortex. In ongoing pursuit of clarification concerning the methods by which discharge occurs, one wonders if there may be a difference between "inactivation" of SNS activity by PNS onset, and "truncation" of SNS activity by the same PNS state. This remains to be seen.

The connections between the orbitofrontal and subcortical ANS processes allow bidirectional communication to occur. These connections enable the CNS to regulate and override ANS responses, particularly in the event of stress. In optimal attachment experiences, misattunement from the mother fosters brief experiences of PNS dominance associated with the withdrawal and immobility response, and reunion transactions with the mother rapidly transform them into a new state of alert inactivity.

Prolonged stressful states are associated with high levels of cortisol. Elevated cortisol is associated with fear, helplessness and despair, depression, and decreased awareness of sensory input. While brief experiences of this state promote PNS development, prolonged or recurrent intense exposure foster passive coping and avoidance strategies associated with unconscious patterned ANS responses for coping with stress.

IV. The Role of the Father and the Developing Verbal Left Hemisphere

During the late practicing period, the child has an increase in oppositional behavior and progressively goes to her father. While she still goes to her mother during periods of stress, this behavior marks the end of the period of maternal imprinting and the transition to a developmental period that culminates when the mother and child successfully renegotiate their relationship through "rapprochement". The period of opposition begins at 15 to 18 months of age, and is associated with an increased interest in the father as a source of arousal induction and reduction.

The father's role, which is not characterized by Schore (1994) to the degree to which the mother's role was described in preceding phases, serves an important function in facilitating safety. The "early experience of being protected by the father and caringly loved by him becomes internalized as a lifelong sense of safety" (Blos, 1984, as cited in Schore, 1994, p. 236). This period fosters growth of the second area of the prefrontal cortex, the dorsolateral cortex, which is the last area of the brain to functionally mature.

The dorsolateral cortex develops the capacity to regulate the dominant verbal left hemisphere and is non limbic. This prefrontal cortex is thus not involved with emotional limbic systems other than through its connection to the earlier maturing prefrontal cortex in the right hemisphere. The primary functions of the dorsolateral cortex include

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conscious awareness, verbal memory, and communication. Dominance of this left hemisphere over the right begins at 3 to 4 years of age and maturation continues until puberty. This stage of physiological brain growth represents a shift from the maternal-experience-dependent maturation of the orbitofrontal part of the prefrontal cortex to a paternal-experience-dependent maturation of the dorsolateral cortex (Schore, 1994).

The dorsolateral cortex forms circuits of connection with subcortical structures completely different from previous right cortical-subcortical connections. The dorsolateral cortex connects to the hippocampus, an important center for memory, as well as the locus coeruleus, which provides most of the norepinephrine stimulation to the central nervous system, both in general and in times of stress. A dopamine circuit that operates within this system promotes motor readiness in striated, *voluntary* muscles, which are involved with high levels of anxiety. This is in comparison to the right-sided ANS-influenced dopamine circuit (ventral tegmental) that fosters sympathetic motor movement in *involuntary* muscles and organs. The developing dorsolateral dopamine circuit therefore differs from the right-sided system of dopaminergic SNS control and norepinephrine mediated PNS regulation. As such, the stress response of the two systems differs.

The dorsolateral cortex is associated with anxiety stress states related to negative affect such as fear, while the orbitofrontal cortex manages positive stress states associated with arousal during attachment interactions. Interestingly, in a reference to the polyvagal system, Schore (1994) states that only the right side connects to and regulates the DVC .

Individuals with problems of the orbitofrontal cortex show lack of inhibition, explosiveness, and high motor activity, which is similar to the behavior of the practicing toddler. Those with dorsolateral lesions, on the other hand, demonstrate little overt emotion, are depressed, and show reduced spontaneity of behavior (Schore, 1994, p. 234). These developmental differences may also eventually present themselves as diseases with related characteristics, such as physiological states of high arousal (high blood pressure) versus low arousal (depression, chronic fatigue).

The paternal-experience-dependent maturation of the dorsolateral cortex

Repeated or intense exposure to overwhelming experiences that cannot be autoregulated, such as occur in misattunement without the support of helpful reunion transactions, results in pathology. The pathology comes from the internalization of repeated experiences of misattuned dysregulated transactions. Early enduring unmodulated painful emotional experiences interfere with the organization of the right cortical system that can regulate and thereby tolerate pain .... These models are imprinted with painful and disorganizing negative affects that cannot be intra- or interpersonally regulated, and are therefore stored in 'unconscious memory' (Schore, 1994, p 446-447).

These memories interfere with the ability of the right hemisphere to effectively interact with the maturing left hemisphere, which consciously avoids the experience of overwhelming pain through mechanisms often referred to as "repression" or dissociation.

> The 'ubiquitous and unrelieved' experience of of [sic] shame, "one of the least tolerable affects for humans' (Malatesta-Magai, 1991), therefore becomes associated with an expectation of a painful disorganizing state which cannot be interpersonally nor intrapersonally regulated, and therefore is consciously avoided or 'bypassed' (Schore, 1994, p. 248).

Overwhelming unconscious memories are the cause of dissociation between left and right hemispheres and are one, if not the only primary source of physiological as well as psychological pathology. These repressed unmetabolized experiences stored in unconscious memory remain unprocessed and show up in other forms, often expressed as nonverbal unconscious symptoms. The manner in which unconscious repressed memories influence symptomatology are explored in more detail in the section on

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trauma (see separate article on trauma).

Relationship between Parts of the ANS

The ability to transition between states of autonomic function is important to the adaptive capacity of the organism.

> The ability to cycle back and forth between these organismic modes [of parasympathetic and sympathetic states] in response to environmental conditions increases survival efficiency. … Chisolm (1990) defines adaptability in the face of socioecological stressors as: 'the capacity of an organism to make a successful response to perturbations in its physical and social environments such that the next time it encounters that same perturbation, or one sufficiently similar, it can respond with less cost' (p. 240, as cited in Schore, 1994, p. 366).

Schore refers to three different modes of autonomic control that affect this capacity to adapt. These modes include:

> a coupled reciprocal mode, a coupled nonreciprocal mode, and an uncoupled mode. In the first, increases in activity in one ANS division are associated with a decrease in the other; in the second, concurrent increases (coactivation) or concurrent decreases (coinhibition) occur in both components; in the third, responses in one division occur in the absence of changes in the other (Berntson, Cacioppo, and Quigley, 1991, as cited in Schore, 1994, p. 323).

These modes are also referred to by another research group, who describe them as "reciprocal inhibition, mutual antagonism, and unilateral activity" (Grossman, Stemmler, and Meinhardt, 1990, as cited in Schore, 1994, p. 324).

Schore's (1994) analysis of the research regarding these modes has lead him to conclude that in the immature organism the two branches of the ANS are initially uncoupled (unilateral activity), and as a result of development in the prenatal and postnatal environment, gradually become reciprocally coupled (reciprocal inhibition). The latter mode provides a wider range of capacity to respond to the environment.

> Reciprocal modes can yield large directionally stable shifts, and are suited for well-defined adaptive adjustments to survival challenges.... One adaptive feature of reciprocal modes of control is a shift in the relative dominance of the two ANS divisions (Berntson et al., 1991, p. 473, as cited in Schore, 1994, p. 324).

The shift mentioned above refers to the gradual increase in parasympathetic dominance that occurs during development. This parasympathetic state is associated with the previously mentioned arousal level of alert inactivity or the conservation-withdrawal mode that enables the organism to respond to stress with "as little involvement, cost or risk as possible" (Schmale and Engel, 1975, as cited in Schore, 1994). This appears to relate to Schore's description of the importance of the phase of misattunement in the late practicing period, which stimulates the development of impulse control and the attainment of moderate, rather than high or low, states of arousal.

The facility with which an organism transitions between ANS states is learned, and is stored as an internal representation.

> The development of more complex forms of self-organization in the first two years is mediated by the appearance of internal representations that shape spontaneous patterns of energy dissipation (Schwalbe, 1991). These stored images come to automodulate processes of energy flow that support survival in a particular environment .... This resilience involves an ability to tolerate signals of negative affect in environmental contexts where threat and lack of social success will interfere with the attainment of biosocial goals (Schore, 1994, p. 367).

The capacity to transition between ANS states is therefore strongly influenced by transactions that occur between caregiver and infant.

> Practicing interactions permanently influence the determination of a set point that reflects the autonomic balance between the sympathetic and parasympathetic components of the ANS, and the reciprocal and nonreciprocal activities of the two limbic circuits. This homeostatic mechanism enables the child to more efficiently self-regulate affect, especially negative affect (Schore, 1994, p. 368-9).

As an organism develops, the ANS response to a novel threat progresses from an uncoupled reaction (in which the response presumably consists of either sympathetic or parasympathetic activity), to one of nonreciprocal coactivation in which both sympathetic and parasympathetic divisions of the ANS increase (Berntson et al., 1991, as cited in Schore). With optimal development, the organism responds to stress with the most adaptive reciprocally coupled ANS response, in which one branch decreases when the other increases. The reciprocally coupled response style consists of a parasympathetically dominant response and is the most energy-efficient mode of interacting with the environment (Schmale and Engel, 1972, as cited in Schore, 1994, p. 367). Such a response is consistent with Porges' (2001) description of the functions of the VVC and the social engagement system. States in which both SNS and PNS are either high or low may be associated, in the long-term, with certain types of diseases. Some forms of chronic fatigue, for example, appear to include an underlying state of high metabolism (associated with hunger, constipation, the need to be active and to "do") with a simultaneous inhibition by a more dominant PNS state (overall fatigue, being cold and depressed, and low blood pressure). Such states appear consistent with the freeze response referred to by Levine (Levine, 1997), in which the state of inhibition is often the most visible.

Conclusion

The development of the maturing nervous system is intimately intertwined with the social emotional environment during the attachment

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period. The role of both parents is important to the optimal development of this system, which influences psychophysiological processes necessary for emotional and bodily self-regulation. These early experiences also influence the capacity to cope with stress and to have satisfying relationships throughout life.

The interconnections and roles of the various components of the nervous system are complex, and patterns of autonomic and central regulation that arise are unique to each individual as a result of his or her set of life experiences. Decreased flexibility and adaptability in transitioning between states of ANS dominance is the result of internalized representations that are formed during the prenatal time frame and the attachment period (Schore, 1994). Imbalances in ANS regulation that develop from nonoptimal environments can consist of inappropriate sympathetic or parasympathetic dominance, a combination of high levels of both (nonreciprocal coactivation), or the independent action of two uncoupled systems.

With sufficient or intense enough exposure to unregulated emotionally overwhelming stimuli in early life, dominance of one or both systems can become the preferred, internalized, patterned response to future stimuli. These responses arise from perceptions that are formed as a result of the sum of experience in life, particularly during the attachment period.

Individuals with secure attachment tend to perceive the world as a safe place with adequate support while those with insecure attachments perceive the world as unsafe and lacking in the capacity to provide support and successful regulation.

Imbalances in nervous system regulation affect metabolic, immune, and endocrine homeostasis as well as psychological processes, and are associated with the development of symptomatology and disease. "Early unregulated shame experiences [play a central role] in the etiology of all primitive psychopathologies and psychosomatic diseases" (Schore, 1994, p. 248). The article on trauma will elucidate the physiology of this process greater more detail.

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