

The Neural Self: The Neurobiology of Attachment

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It is its basis in biology that makes attachment theory unique among theories of psychology and child development. From the biological perspective, attachment is simply an evolutionarily-evolved process to ensure species survival, and is thus as much a part of our biology as that of any animal. From this perspective, cognitive schema and the resulting mental map is not merely a psychological phenomenon, but a physical entity, hard-wired into neural circuits and reflected in neurochemical and electrical activity within the central nervous system. The mental map into which our experiences and memories are imprinted is thus a neurobiological structure, the result of synaptic processes, out of which human cognition and behavior emerges, resulting in LeDoux's (2002) description of our "synaptic" self. Siegel (2001) describes the pattern and clusters of synaptic firing as "somehow creat(ing) the experience of mind" (p. 69). He writes that "integration" reflects the manner in which functionally separate neural structures and processes cluster together and interact to form a functional whole – in this case, our selves.

Because neurobiology affects behavior, behavior results in experience, and experience effects changes in neurobiology, we recognize that everything we do and experience has an internal neurobiological and an external behavioral counterpart. Everything is physical at the neural level, including emotion and thought, but the physical activity of the brain is translated into non-physical cognitive and emotional mental processes. In turn, these result and are expressed in behavior and social interactions, which stimulate cognition and affect, and are transcribed back into the brain through resulting synaptic activity and the encoding of experience in neural memories.

There is at all times, then, a level beneath the exterior at which our behaviors, thoughts, and emotions are the result of synaptic firing and patterns. Accordingly, our psychological and behavioral states are defined and shaped by neurobiological processes (nature) which are themselves shaped and defined by the experience (nurture). Of this LeDoux (2002) writes "people don't come preassembled, but are glued together by life...What's interesting about this formulation is not that nature and nurture both contribute to who we are, but that they actually speak the same language. They both ultimately achieve their mental and behavioral effects by shaping the synaptic organization of the brain" (p. 3).

Brain development is associated with experiences in the environment that trigger and produce neural activity. Whether the experiences are positive or negative, neural activity occurs, responding and adapting to those experiences. Adaptations that we consider positive are those that result in neural developments that enhance our ability to function effectively in the world. Conversely, neural adaptations that we consider to be negative impair our capacity to function optimally with respect to prosocial relationships and behaviors. In the latter case, maladaptation (or negative adaptivity) is most associated with unresolved stress, produced by events experienced by the brain as traumatic. Accordingly, it is not possible to discuss brain development in light of attachment processes without relating poor attachment experiences to stress and trauma and their resulting neurological responses, and in which enhanced neural and psychosocial functioning is possible only when the source of the stress is resolved.

The Interactive Brain: The Assemblage of Neurology and Experience

The Commission on Children at Risk (2003) asserts that the processes by which we form social attachments and remain attached are biologically primed and discernible in the structure of the brain, and that the provision or absence of nurturance in early childhood development directly affects the development of brain circuitry. In particular, four primary aspects of neurology are pertinent to understanding attachment at the neurological level, as well as understanding attachment-related pathologies.

1. Although the brain is primed for attachment at birth, neural processes develop and unfold over time in concert with the environment, and are both receptive and adaptive. As Spear (2000) has noted, “biology is not destiny, and is modifiable by social behavior and other experiences” (p. 447). That is, the morphology of the brain, including the shape and volume of its structural components, is formed, modified, and re-shaped by environmental stimulus and input. As the brain develops, its structure is, in effect, shaped, sculpted, and re-shaped by the environment, notably through the processes of “pruning” and “parcellation.”
2. The ability of the brain to form synaptic connections, or neural circuits, describes what we mean by neural “plasticity.” This refers, not to the development of new areas of the brain, but the development and strengthening of new synaptic connections and possible morphological changes in brain volume, and particularly in the hippocampus, one of the few areas of the brain in which new neural cells continue to develop throughout life. Through treatment, we can hope to take advantage of the ability of the brain to form, not new structures, but new neural circuits and synaptic connections. Here, we hope to develop the capacity for a different level of brain functioning in which formerly less active areas are brought into use, and the neural “net,” or the manner in which the brain integrates simultaneous activity across the brain and across both hemispheres, is thus strengthened. It is this process to which we refer when we say “brain-based learning.”
3. The brain is not only shaped to some degree by its environment, but through its expression in affect, cognition, and behavior, the brain, in turn, affects and colors all future experience and, thus, the environment itself. This concerns the “interactive” brain, or the manner in which environment shapes the brain and the brain shapes the environment. With neural structures that add emotion and meaning to environmental information, we wind up with a brain that is not just a neutral receiver, but an interpreter of experience and a shaper of its environment. Here, we recognize the mutuality and inseparability of nature and nurture, aspects of a larger phenomenon by which we become who we are.
4. We are interested in the consolidation and amalgamation of social experiences into emotional and memory systems, which, in effect, constitute the autobiography of the brain. We are, of course, particularly interested in the effects of the attachment experiences on the early brain, and its direct and indirect affect on and interaction with neurological development. Siegel (2001) writes that when “certain suboptimal attachment experiences occur, the mind of the child may not come to function as a well integrated system” (p. 70).

The Use-Defined Brain

We also recognize that the morphology and the structures of the brain are influenced by and respond to the environment and its inputs, and is thus, in part, a “use-defined” brain. That is, environmental conditions and interactions affect neurological development. Hence, the brain that develops is an adaptation to, and to some degree a reflection of, the external world in which the individual who carries that brain lives. This reflects the idea that our brains are shaped by repetitive neural experiences that result in the formation of strong synaptic connections (“cells that fire together, wire together”), in which the mind that develops is, partly at least, the result of repeated early experience or adaptation to early conditions that have become synaptically sculpted (hard wired) into neural circuits. The way in which the brain experiences and responds to its environment primes it for future expected experiences and activities; creates the conditions for “long term potentiation,” which is essentially the process by which the brain learns and remembers (and is thus trained) at the synaptic level; and stimulates morphological development, or the shape and size of parts of the brain.

Takahashi, Nowakowski, and Caviness (2001) report that repetition and overlearning of specific operations in early childhood results in enlarged volumes in related areas of the cortex. Thus, they write that the brain is effectively “built” by its specific experiences in the environment, as an *adaptation* to the environment. Hence, the brain becomes shaped by, not just its evolutionary function and its genetic inheritance, but also its interactions with the world and how it responds to that world.

The Role of Attachment in Neurological Development

Secure attachment implies a bond of emotional communication between the infant and the primary caregiver. For this to occur, the mother must be not only psychologically but also biologically attuned to the external and internal states of arousal in her child. This biological connection results in attachment experience becoming “hard wired” into the brain. From this perspective, Schore (2002) writes that attachment is the outcome of the child’s genetically predisposed biology and the specific caregiver environment, representing biological attunement and synchronicity between the brains of the mother and child. Thus, the learning process that mediates the development of attachment is the result of a biological process imprinted through infant-maternal stimuli and behavior. An early history of mistuned or poorly attenuated mother-child interactions heads the neurobiological attachment system along a different trajectory than that of the child whose mother is well-tuned and responsive to its needs. With a history of poor or traumatic interactions, the infant/toddler is exposed to a primary caregiver who triggers, and is unable to or does not repair, long lasting dysregulated states (Stern, 2000). These negative states lead to significant biochemical alterations in the maturing right brain, and because they occur during the brain growth spurt in early childhood development, long lasting *states* become *traits*, and are thus embedded into the core structure of the brain and, hence, the evolving personality (Schore, 2002).

The Stressed Brain

As noted, the development of the brain is significantly tied up with stress, the absence of stress, or the ability to resolve stress, and the absence of a nurturing caregiving environment is antithetical to this neurodevelopmental need. Inadequate caregiving produces or fails to resolve stress because it is directly responsible for stress through active abuse or neglect, because it fails to recognize or protect the child against stress, or because it is unable to prevent or repair stress and soothe the child. In each case, inadequate caregiving not only fails to provide the nurturance and guidance required for the development of self-regulation on a neural level, but contributes to the activation of the neurobiological stress axis and the development of stress related neural circuits and related behavioral sequelae. In fact, it is difficult to discuss the neurobiology of attachment without considering physical processes within the brain and body that are triggered by stress. These either facilitate effective stress reduction, and hence promote self-regulation, or produce a frequent state of anxiety experienced at the neural level that must be constantly managed.

The early neural circuitry of the stress system is located in the early developing right brain, the hemisphere that is dominant in the control of vital functions that support survival and the human stress response, and the hemisphere most active and dominant during the first two years of life. Infants under 2 years show higher right than left hemispheric volumes, and during the first two years attachment experiences are thought to directly influence the experience-dependent maturation of the right brain. These of course include experiences with nurturing and sensitive caregivers, as well as traumatizing caregivers, which in either case are presumed to impact the child’s attachment security and ability to develop stress coping strategies and self-regulatory skills.

Siegel (1999) writes that children who experience severe emotional deprivation during the first three years of their lives, when the right brain is most dominant, are at risk for losses in the structural development of their right hemispheres, especially in the region of the orbitofrontal cortex. The proposal is that right orbitofrontal cortex development is limited in development by negative or poor attachment experiences; that the neurology of the prefrontal cortex is shaped by early experience, and attachment in

particular; and, of great importance, that early experiences become embedded into the neural structure and protoconsciousness of the orbitofrontal cortex, and hence the developing mental map into which our cognitive schema and implicit theories about the world are embedded, or the internal working model as it is known in attachment theory.

With respect to the brain's experience of and response to stress, Teicher (2002) writes that the neurobiological effects of early trauma contribute to the under-development of left brain regions and neural biases to right brain processes. In response to ongoing maltreatment and/or trauma, or other adverse conditions in the environment, the focus on right hemisphere dominated brain processing and its rapid, self protective responses, is an appropriate adaptation to an adverse environment, rather than evidence of malfunction or damage. Like others, Teicher concludes that the brain is designed to respond to and be shaped by experience, and considers the bias towards right brain processes in the stressed brain to be *adaptations* to unsafe external environments, rather than *malformations* of the brain.

Attachment, Attunement, and Self-Regulation

Schore (2001a, 2001b, 2002) describes the attunement of the attachment process, through face-to-face contact between mother and child, as not only reducing anxiety-produced stress and thus regulating neurochemical processes, but also teaching the skills of self-regulation to the child, in effect through right brain-to-right brain non-verbal communication. According to Siegel (1999), the emotional state of one individual is transmitted and communicated to another through face-to-face contact, contributing to the developing child's capacity for theory of mind.

The attuned-attached relationship produces calming and affiliative pair-bonding hormones in both parties, such as the neuropeptide oxytocin, which also appears to alleviate separation distress and other emotional processes, and is associated with positive social interactions and behavior, and maternal nurturance (Carter, Lederhendler, & Kirkpatrick, 1997; Panksepp, Nelson, & Bekkedal, 1997). Vance (1997) notes that is obvious that secure relationships serve as the primary antidote for fearful or painful experiences. He writes that the release of oxytocin in response through emotional and physical contact not only promotes the exclusivity of relationship bonds, but explains why childhood distress and juvenile aggression often abate as a result of *specific* relationships rather than any social relationship, whether through secure maternal attachment or close mentor relationships.

Schore (2001b) describes the development of attachment as an interactive regulator that allows for the bioregulation of emotion. Conversely, he writes that negative attachment experiences induce neurobiological development that inhibits bilateral integration between the orbitofrontal cortices, limiting the capacity for both self-regulation and reasoned behavioral decisions. He describes the essential task of the first year of human life as the creation of a secure attachment bond, developed through emotional communication between the infant and parent, shaped by the interaction of the infant's biological predispositions and the attachment environment that results from maternal care (Schore, 2002). Schore (2001a) asserts that attunement and reciprocity in the infant/maternal relationship plays a fundamental role in brain organization and the development of regulatory processes of the central nervous system. In addition, Siegel (1999) proposes that when mutual "resonance" between the right brains of mother and child are absent during the first three years, the child is unlikely to adequately develop the capacity to reflect upon or understand self or others, inhibiting the development of the capacity for metacognition, as well as self-regulation.

The Neural Self: The Promise of the Changeable Brain

In a neurological model, we recognize that the experience of mind and selfhood is neurologically embedded into the central nervous system, contained within the hypothetical internal working model, or mental map. In the neurological model, the origins and imprinting of attachment involve attuned and mutual interactions between mother and infant, through face-to-face, body-to-body, and, Siegel and

Schore would say, right brain-to-right brain contact. This stimulates neurochemical and electrical transmissions and impulses within the child's central nervous system. These stimulate or result from hormonal release, the firing of neurons across synaptic terminals, the creation of synaptic connections, the chemical and emotional encoding of memory, and the development of the "neural self."

Into this neural self, the neurobiological counterpart of the self in-society,^[1] we hope to instill a view of self as efficacious and capable and a view of others as responsive and worthy, and to whom we feel connected. However, it is the early and subsequent interactions between the child and others (initially, the mother and other major attachment figures, but increasingly other caregiving and affiliative figures) that allows one to experience self, others, and social interactions in this manner. Although we cannot undo previously developed neural processes, through the promise of brain plasticity and the effect of relationships on plasticity, we have the opportunity to modify existing neural pathways, condition currently developing synaptic connections, and influence the development of yet-to-be formed neural circuits.

This is most likely to occur, not through our words, but through the provision of experiences recognized on a neural level and which the brain colors with emotions and integrates through practice. This is what we mean by brain-based learning, focused on attunement, stress management, nurturing relationships that stimulate the attachment circuits of the brain, and the enhancement of left-right brain integration and processing. What we have, then, is an understanding of how external experience, including early attachment and on-going social experience, interacts with the brain to shape neural processes and the manner in which the brain responds to and shapes its environment. By changing that environment, we can hope, in conjunction with the brain's plasticity, to change the way the brain, and hence the neural self, functions in and experiences the world.

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^[1] Self-in-society conceptually represents the experience of selfhood and the subjective experience of self in its interactions with the social world.

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