ARTICLE

TOWARD AN INTERPERSONAL NEUROBIOLOGY OF THE DEVELOPING MIND: ATTACHMENT RELATIONSHIPS, "MINDSIGHT," AND NEURAL INTEGRATION

DANIEL J. SIEGEL
UCLA School of Medcine

ABSTRACT: This article reviews findings from a wide range of scientific disciplines in exploring the idea that the mind develops at the interface between human relationships and the unfolding structure and function of the brain. Recent discoveries from a number of independent fields, including those of developmental psychology and cognitive neuroscience, can be synthesized into an integrated framework for understanding how the brain gives rise to mental processes and is directly shaped by interpersonal experiences. This "interpersonal neurobiology" (Siegel, 1999) presents an integrated view of how human development occurs within a social world in transaction with the functions of the brain that give rise to the mind. This framework suggests some basic principles for conceptualizing the essential experiential ingredients that may facilitate the development of the mind, emotional well-being, and psychological resilience during early childhood and perhaps throughout the lifespan. At the core of these processes is a fundamental mechanism of integration which can be seen at a variety of levels, from the interpersonal to the neurological. Integration may be conceptualized as the basic process that secure attachments facilitate in promoting psychological well-being. This article will summarize these concepts and offer some ideas about their implications for practice and future investigations.

RESUMEN: Desde el punto de vista de una amplia gama de disciplinas, este artículo revisa los resultados de exploración de la idea de que la mente se desarrolla al contacto entre las relaciones humanas y la extendida estructura y función del cerebro. Descubrimientos recientes en un cierto número de campos independientes, entre los cuales se incluye la sicología del desarrollo y la neurociencia cognitiva, pueden ser sintetizados dentro de un marco integrado para comprender la forma como el cerebro da inicio a los procesos mentales y es directamente formado por las experiencias interpersonales. Esta "neurobiología interpersonal" (Siegel, 1999) presenta un punto de vista integrado de cómo el desarrollo humano ocurre dentro de un mundo social en transacción con las funciones del cerebro que dan origen a la mente. Este marco sugiere algunos principios básicos para conceptualizar los esenciales ingredientes de la experiencia que pudieran facilitar el desarrollo de la mente, el bienestar emocional, así como la resistencia sicológica durante los primeros años de la niñez, y quizás a través de toda la vida. En el centro de estos procesos hay un mecanismo fundamental de integración el cual puede ser visto a diferentes niveles que van desde lo interpersonal hasta lo neurológico. La integración puede ser conceptualizada como el proceso básico que toda relación afectiva segura facilita al promover el bienestar sicológico. Este artículo resumirá estos conceptos y ofrecerá algunas ideas acerca de sus implicaciones para la práctica y futuras investigaciones.

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RÉSUMÉ: Cet article passe en revue des conclusions d'une grande gamme de disciplines scientifiques en explorant l'idée selon laquelle l'esprit se développe à l'interface entre les relations humaines et la structure et la fonction en développement du cerveau. Les découvertes récentes dans un certain nombre de domaines indépendants, y compris ceux de la psychologie du développement et de la neuroscience cognitive, peuvent être synthétisées en une structure intégrée pour la compréhension de la manière dont le cerveau fait naître des processus mentaux et est directement formé par des expériences de communication. Cette "neurobiologie communicative" (Siegel, 1999) présente une vue intégrée de la façon dont le développement humain se produit au sein d'un monde social en transaction avec les fonctions du cerveau qui font naître l'esprit. Cette structure propose quelques principes de base pour la conceptualisation des ingrédients d'expérience essentiels qui peuvent faciliter le développement de l'esprit, le bien-être émotionnel, et le ressort psychologique durant la petite enfance et peut-être durant la vie entière. Au coeur de ces processus se trouve un mécanisme fondamental d'intégration qu'on peut observer à plusieurs niveaux, du niveau communicatif au niveau neurobiologique. L'intégration peut être conceptualisée comme un processus de base que les attachements solides facilitent en promouvant le bien-être psychologique. Cet article résumera ces concepts et offrira quelques idées sur leurs implications pratiques et des recherches à venir.

ZUSAMMENFASUNG: Dieser Artikel beurteilt eine Reihe von wissenschaftlichen Disziplinen, die sich zur Idee, dass der Geist sich an der Schnittstelle zwischen menschlichen Beziehungen und den sich öffnenden Strukturen und Funktionen des Gehirns entwickelt, geäussert haben. Neue Entdeckungen aus einer Reihe von unabhängigen Forschungsrichtungen—unter Einschluss der Entwicklungspsychologie und der kognitiven Neurologie—können in einen integrativen Bezugsrahmen, wie das Gehirn intellektuelle Prozesse entwickelt und diese direkt von zwischenmenschlichen Erfahrungen geprägt werden, zusammengeführt werden. Die „zwischenmenschliche Neurobiologie" (Siegel, 1999) zeigt eine integrierte Sichtweise, wie menschliche Entwicklung in Übereinstimmung mit den Gehirnfunktionen in einer sozialen Welt auftritt, welche die Entwicklung des Geistes ermöglicht. Dieser Bezugsrahmen schlägt einige grundlegende Prinzipien vor, um unverzichtbare experimentelle Zutaten zu entwerfen, die die Entwicklung des Geistes, des emotionalen Wohlgefühls und der psychologischen Ausgeglichenheit in der frühen Kindheit und vielleicht während des ganzen Lebens, erleichtern können. Im Herzen dieser Prozesse befindet sich ein fundamentaler Mechanismus der Integration 1 der auf einer Vielzahl von Ebenen gesehen werden kann, von der zwischenmenschlichen bis zur neurologischen. Die Integration kann als der zugrundeliegende Prozess gedacht werden, der sichere Bindung erleichtert und dadurch psychologisches Wohlgefühl ermöglicht. Dieser Artikel wird diese Konzepte zusammenfassen und einige Ideen über ihre Bedeutung für die Praxis und zukünfge Forschung anbieten.

抄録：この論文は、人間の関係性と広げられつつある脳の構造と機能との境界面にこころが発達するという見解を探求する、広範囲の科学領域からの発見を総説する。多くの独立した科学分野における最近の発見は、発達心理学と認知神経科学の分野を含め、どのように脳がこころの過程を生み出し、そして対人関係の体験によって直接的に形づけられるのかを理解するための統合された枠組みへと、総合されることができる。この「対人関係神経生物学](Siegel,1999)は、こころを生み出す人間の発達が、社会的世界の中で脳の機能との交流によってどのように起こるのかの統合した見解を発表した。この枠組みは、早期児童期およびおそらく一生をとおして、こころの発達、情緒的健康、そして心理学的回復力を促進するであろう、基礎的な経験上の構成要素を概念化するための、いくつかの基本原則を示唆する。これらの過程の中核には、様々な水準に、対人関係の水準から神経学的な水準までに見られることができる、統合という基礎的な機能がある。統合は、心理学的な健康を増進するうえで、安全な愛着が促進する基礎的な過程として概念化されるだろう。この論文はこれらの概念を要約し、実践と将来の研究へのそれらの意味についての見解を提供するだろう。

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EXPERIENCE, MIND, AND BRAIN

The infant is born into the world genetically programmed to connect with caregivers who will become "attachment figures" in the child's life (Cassidy & Shaver, 1999). These attachments can be formed to the mother, to the father, and to other individuals who are intimately involved in providing care for the growing child. Attachment is considered a basic, in-born, biologically adaptive "motivational system" that drives the infant to create a few, selective attachments in his life. These attachments provide a relationship in which the infant will: (1) seek proximity to the attachment figure; (2) have a sense of a safe haven—in which when he is upset the attachment figure will soothe his distress; and (3) develop an "internal working model of a secure base"—an internal schema of the self with the other, self-with-attachment-figure—that will provide him with a security enabling him to explore the world, have a sense of well-being, and to soothe himself in times of distress in the future (Bowlby, 1969).

Though the attachment system is "hard-wired" in the brain, the experiences that an infant has will directly shape the organization of that system. Experience involves the activation of neurons in the brain that respond to the sensory events from the external world—or to the internally generated images created by the brain itself (such as our experience of recalling times from the past) (Gazzaniga, 1995; Kandel & Schwartz, 1992). Neurons are the basic cells of the brain. They are long cells that contain a central nucleus and sending and receiving extensions that connect with other neurons. The basic mechanism of neural function is this: the equivalent of a flow of electrical activity (called an "action potential") passes down the long "axon" or neural length to its end where it functionally connects with other neurons at a "synapse." The electrical impulse causes the release of a neurotransmitter (a chemical) that flows across the small synaptic space to activate (or inhibit) the receiving neuron. That receiving neuron, if activated by the release of enough neurotransmitter, sends its electrical signal down its long length to release neurotransmitters at its own synaptic connections. The key issues are these: each neuron connects to an average of 10,000 other neurons! There are about 100 billion neurons, with over 2 million miles in their collective length. In addition, there are thought to be an incredible range of possible "on-off" firing patterns within this complex, spider web-like net of neural connections—estimated to be about ten times ten one million times. The fact that our brains can be organized in their functioning is quite an accomplishment!

The processes of the mind are thought to emanate from the activity of the brain (Mesulam, 1998). When particular circuits in the brain (interconnected neurons, groups of neurons, and clusters of groups of neurons that form specific pathways and systems of the brain) are activated, various mental processes are created. The brain creates a "neural map" or "neural net profile"—a specific pattern of neural firing in particular regions—that serves to create a "mental image," such as a sensory image, or the linguistic representation of a concept or object. The term "representation" is sometimes used to refer to a neural map or to a mental image that serves as a symbol for something. At this point in the history of science, we do not yet know exactly how the brain "map" creates the mind "image" (Damasio, 1999). Cognitive neuroscientists generally agree, however, that it is the pattern of firing in the map—the particular clusters of neurons activated in a specific pattern—that, somehow, creates the experience of mind.

The entity we call the mind can be understood in the simplest terms as patterns in the flow of energy and information (Siegel, 1999). As we will see, energy and information can flow within one brain, or between brains. In this manner, the ways in which energy and information flow within an individual or between two individuals helps create the experience of mind. There is an exciting convergence of findings from the neurosciences and from the developmental "behavioral" sciences that allow us to see a unity of knowledge, or consilience (Wilson,

1998), on a deeper plane than each individual field of study alone can portray. Though our scientific studies and our words may emphasize a focus on either brain or mind, the reality appears to be that the processes of the mind emanate from the structure and function of the brain. The brain itself is an integral part of the central nervous system, which is fundamentally interwoven within the whole body. Thus, though we may speak of the mind as emanating from the neurophysiological processes of the brain, this statement is an abbreviated way of referring to the flow of energy and information within the brain as a fundamental part of the functioning of the body as a whole. The patterns in the flow of energy and information, the essence of the mind, are a product of both bodily (neurophysiological) processes and interpersonal interactions.

Another important general point is this: although we focus on particular regions and circuits of the brain, the fact is that the brain is a complex set of integrated systems that tend to function together. The mind is created from the whole brain. "Integration"—the ways in which functionally distinct components come to be clustered into a functional whole—may be a fundamental way in which the nervous system functions. As we will see, when certain suboptimal attachment experiences occur, the mind of the child may not come to function as a well integrated system. We will explore the important interpersonal elements of communication that help to foster, or to hinder, the development of such neural integration. In a text entitled *The Developing Mind* (Siegel, 1999), I have proposed that integration is a core process essential for mental well-being within the individual and the family, and perhaps fundamental for the healthy functioning of a nurturing community.

DO ATTACHMENT RELATIONSHIPS INFLUENCE BRAIN DEVELOPMENT?

We now know that both genetically encoded information and neural activation itself can result in the activation of genes that leads to the creation of the proteins necessary to shape the structure of the brain (Kandel, 1998; Nelson & Bloom, 1997). Experience involves the activation of neurons. In this manner, experience shapes the function of neural activity in the moment, and can potentially shape the continually changing structure of the brain throughout the lifespan. Recent findings from neuroscience in fact suggest that the brain remains plastic, or open to continuing influences from the environment, throughout life (Barbas, 1995; Benes, 1998). This plasticity may involve not only the creation of new synaptic connections among neurons, but also the growth of new neurons across the lifespan. The capacity for attachment classifications to change beyond the early years of life may be related to this ability of the brain to continue to grow in response to experiences across our life times.

A public debate within the popular media erupted in the United States at the end of the 1990s over how important the first years of life, or parents in general, are in children's development. The media has focused on a few books written to discount the impact of early experience—or any parenting experience—in helping to shape children's minds (Brewer, 1999; Harris, 1998). In general, these publications make these claims by dismissing the major contribution of attachment research to understanding the important part caregivers play in children's lives, especially in the early years. Arguments used to diminish the importance of attachment findings include the possible role of genetics in determining the outcome of attachment studies and the finding that if attachment status can change then these studies do not demonstrate a "critical" period that is irreversible. With a quick dismissal on these grounds, these authors urge the reader to consider the important role of genetics, peers, or later years of development. As discussed below and in detail in *The Developing Mind*, attachment researchers have indeed not yet carried out the important direct procedures to clarify the role of genetics

in determining the attachment patterns. Given the fact that most parents in these studies are genetically related to their offspring, it is wise to be cautious about inferring causal attributions rather than statistically significant associations from present studies. A number of indirect analyses, however, suggest that attachment classifications are determined primarily by relationship experiences and not by genetic inheritance.

Several findings point to the experiential role of relationships, rather than that of genetic information, in determining attachment status. In brief, these findings include the following: (1) the child's attachment classification is independently correlated to each parent and is related to that parent's Adult Attachment Interview (AAI) findings (discussed below). In other words, one child can have two attachment patterns that are each specific to a given parent and correlate with a feature of that parent; (2) the child's temperament, thought to have a genetic underpinning, does not predict the child's attachment pattern; (3) the individual factors in adults that have been found to have a high degree of genetic influence, including intelligence, memory, and personality test scores such as those of the MMPI, have not been found to correlate with the AAI findings. This finding, plus recent studies that suggest that the AAI is a measure of the child's attachment experiences, support an experiential origin for the AAI findings; and (4) the AAI findings of a pregnant woman and her husband can independently predict the child's attachment pattern some 18 months later, suggesting that the AAI is not a measure of the parent's response to parenting that particular child.

Attachment relationships are important in the unfolding of the emotional and social development of the child during the early years of life. Development is an ongoing process, and so close, emotionally involving relationships may continue to influence us throughout the lifespan. As we will see, the importance of the first years may be that the brain structures that mediate social and emotional functioning begin to develop during this time in a manner that appears to be dependent upon interpersonal experience. Although at this point in attachment research there is little direct evidence from neurobiological studies in humans of the impact of relationships on brain function, there is a great deal of consilience (Wilson, 1998) across a number of fields, including those studying attachment, child development, cognitive neuroscience, complex systems, developmental psychopathology, neurology, and psycholinguistics. This convergence of findings from a range of independent fields of research suggests a direction in which academicians may understand how the findings in their own work may relate to those from other disciplines. For clinicians, educators, and policymakers, this interdisciplinary view offers a broad perspective on how to understand the role of science in understanding the profound importance of an interpersonal focus on the subjective experience of developing children.

The argument that we do not have "enough direct neuroscience" to state that attachment relationships shape the developing brain evades the essential findings of cognitive neuroscience that experience in general shapes neuronal function and brain architecture (Milner, Squire, & Kandel, 1998). Furthermore, the patterns of development of children with distinct attachment classifications suggests that the minds of these individuals are functioning in quite distinct manners. For example, the paucity of autobiographical recall in the avoidantly attached children and their parents with Dismissing Adult Attachment findings support the notion that certain aspects of their minds are functioning in a unique manner (Siegel, 1999). As cognitive neuroscience findings enable us to better understand the neural processes involved in autobiographical recollection, we can begin to hypothesize the mechanisms by which the avoidantly attached children and their parents with a Dismissing state of mind with respect to attachment may have distinct neurobiological functions subsuming these distinctions. Future research is necessary to confirm these proposals stemming from this convergence of findings. This process of analysis is, in fact, the manner by which science advances (Wilson, 1998). Those who help

children develop should be aware of the nature of our knowledge, the limitations, and practical implications of our current science, and the potential directions for future investigations.

There is a genetically driven overproduction of neurons prior to birth and of synapses during the first three years of life. This finding is relevant for practitioners because it means that the brain appears to have a built-in mechanism to create the neurobiological foundation of the developing mind. As the child grows, this neural substrate will serve as the structure from which basic experiences will "carve out" the neural connections governing basic processes such as perception and motor activity. This early form of brain development, called by some neuroscientists an "experience-expectant" process (Greenough & Black, 1992), functions by way of the genetically encoded synapse formation that requires a minimal amount of "species-expectable" environmental stimulation, such as exposure to light or sound. The "pruning" or selective elimination of the genetically produced excess in connections shapes development. Disuse ("use-it-or-lose it") or toxic conditions, such as with excessive stress (as in child abuse), can lead to the elimination of existing synapses. The important point is that some neurobiologists point out that circuits must be only minimally stimulated to maintain the neurons and their interconnections.

A contrasting process, sometimes called "experience-dependent" development, occurs by way of the establishment of new neural connections induced by experience. Experience, therefore, can alter brain structure by leading to either the maintenance and strengthening of existing synapses, or by the experience-driven creation of new synaptic connections. Many authors do not even make this distinction between experience-expectant and experience-dependent growth, focusing instead on the basic mechanisms of neural development that shape synaptic formation and function. The end result is similar for these experience-influenced processes: neural connections are maintained, strengthened or created. The generally held belief in neural science is that the patterns of neuronal connections determine the ways in which the brain functions and the mind is created. Because experiences with others early in life are so important for human development, I have earlier stated that "Human connections create the neural connections from which the mind emerges" (Siegel, 1999). It is in this manner that interpersonal experiences directly shape the genetically driven unfolding of the human brain.

These distinctions between "expectant" and "dependent" processes are in the midst of being clarified by researchers. I point them out here for two reasons. One is that there is no need to bombard infants or young children (or possibly anyone) with excessive sensory stimulation in hopes of "building better brains." This is an unfortunate misinterpretation of the neurobiological literature—that somehow "more is better." It just is not so. Parents and other caregivers can "relax" and stop worrying about providing huge amounts of sensory bombardment for their children. This synaptic overproduction during the early years of life has been proposed to allow for a likelihood that the brain will develop properly within the "average" environment that will supply the necessary minimal amount of sensory stimulation to maintain necessary portions of this genetically created and highly dense synaptic circuitry. More importantly than excessive sensory stimulation in the early years of development, however, are the patterns of interaction between child and caregiver. Attachment research suggests that collaborative interpersonal interaction, not excessive sensory stimulation, can be seen as the key to healthy development. Recent independent findings in neurobiology give us some possible explanations for why this may be true, but these studies are not necessary for us to know about these essential elements of development. Neurobiology can help us know how to pursue further research questions to deepen our understanding of the developmental mechanisms underlying these findings from attachment studies.

Because of the ongoing creation of synapses in response to experience and the early excessive growth of new synapses, which eventually become pruned to adult levels by the end

of puberty, it is clear that development may occur over a prolonged period of time. Whether development occurs from the elimination of the excess in synapses, or in the creation of new ones based on experience, interaction with the environment can provide children (and adults) with developmental impetus for years to come. The recent findings from neuroscience that the adult brain remains "plastic"—or open to changes in response to experience—throughout the lifespan in no way decreases the importance of the first years of life in establishing patterns of neuronal growth that subsume very important functions. Development is about the creation of specific circuits, not merely the overall amount of synapses in the brain. The ways in which the circuits regulating emotional and social functioning develop may be profoundly influenced by interpersonal experience beginning early in life. Recent explorations of the convergence of neurobiological findings in experimental animals and in humans with findings from attachment research, (as I summarize in *The Developing Mind* and also as discussed in the work of Allan Schore noted in the references) have suggested, in fact, that patterns of interpersonal communication may have a powerful effect on the how neural circuits grow and develop within the brain in the early years.

There are circuits that are responsible for emotional and social functioning (not just perception and motor action) that come "on-line" during the first years of life. While this period may not be the "last chance" for ongoing development in these areas, it is a time when basic circuitry is being established for the first time. Books that discount the importance of the early years, or of attachment in general, fail to examine what we know about the development and the possible neurobiological foundations of emotional and social processes. The orbitofrontal region, which is central for a number of processes such as emotion regulation, empathy, and autobiographical memory, may have an experience-influenced development that depends upon the nature of interpersonal communication during the early years of life. Interactions with "older people," with attachment figures, are essential during this time to create the contingent, collaborative communication necessary for the proper emotional and social development of the child. It is not a matter of overwhelming "enrichment" or excessive sensory stimulation that is needed during this time, but one of attunement between adult and child. This collaborative, attuned communication establishes patterns of interaction by which the caregiver can regulate the child's positive and negative emotional states. These emotion-regulating *interactions* are required for the experientially influenced maturation of the infant's developing emotional and social brain.

BRAIN DEVELOPMENT AND MEMORY

During the early years of life, the basic circuits of the brain are developing which will be primarily responsible for a number of important mental processes involving emotion, memory, behavior, and interpersonal relationships (Schore, 1994, 1996, 1997). These processes include the generation and regulation of emotion, the capacity for "response flexibility" or mindful, reflective behavior (Siegel, 1999), the autobiographical sense of self and the construction of a "self-narrative," the capacity to understand and care about the minds of others, and the ability to engage in interpersonal communication. Independent studies in attachment suggest that patterns of interaction between caregiver and child have an important impact on the development of these mental processes (Cassidy & Shaver, 1999; Toth, Cicchetti, Macfie, & Emde, 1997).

Development shapes the brain by altering the strength of the synaptic connections within the brain. These alterations can take a number of forms: (1) synapses formed from primarily genetically encoded information can be strengthened, weakened, or eliminated (pruned); (2) new synapses can be formed in response to experience; (3) temporary increases in the linkages among neurons can occur in the case of short-term or working memory; (4) the laying down

of myelin (a sheath around more mature neuronal fibers) functionally enhances the neural connectivity by increasing the speed of conduction of the electrical "action potential" down the axon length; and (5) regardless of the origin of the synapse, genetic information, toxic substances, and stressful or absent experiences can lead to the elimination of synapses.

Memory is the way in which past experience is encoded in the brain and shapes present and future functioning (McClelland, 1998; Milner, Squire, & Kandel, 1998). The processes of memory and those of development in fact are closely aligned. For the first year of life, the infant has available an "implicit" form of memory that includes emotional, behavioral, perceptual, and perhaps bodily (somatosensory) forms of memory. Implicit memory also includes the generalizations of repeated experiences, called "mental models" or schema (Johnson-Laird, 1983). The way that the brain readies itself for retrieval of certain memories in response to specific cues is also a part of implicit memory and is called "priming" (Schacter & Buckner,1998). When implicit memories are activated, they do not have an internal sensation that something is being recalled. They merely influence our emotions, behaviors, or perceptions directly, in the here and now, without our awareness of their connection to some experience from the past.

By the middle of the second year, children begin to develop a second form of memory, "explicit" memory (Bauer, 1996). Explicit memory includes two major forms: factual (semantic) and autobiographical ("episodic") (Tulving, Kapur, Craik, Moscovitch, & Houle, 1994). For both types of explicit memory, recollection is associated with an internal sensation of "I am recalling something now." For the later developing autobiographical memory, there is also a sense of the self at a time in the past.

As we can see, infants will only have implicit forms of recollection available to them. In this manner, the shaping of their minds in the earliest months of life will never be explicitly available to them as they grow. This is the normal, universal finding of "childhood amnesia" and is thought to be due to the genetically determined timing of the unfolding of brain structures needed for explicit memory (Nelson & Carver, 1998). In particular, the maturation of the hippocampus in the medial temporal lobe does not occur until after the first birthday, and is thought to be essential for explicit encoding (Bremner & Narayan, 1998). Later on, the front part of the frontal regions of the neocortex (the upper part of the brain)—an area called the prefrontal cortex—will mature enough to allow for the beginning of autobiographical recall.

One of the important messages of these findings is that although we may never recall "explicitly" what happened to us as infants, the experiences we had with our caregivers have a powerful and lasting impact on our implicit processes. These experiences, as we have seen, involve our emotions, our behaviors, our perceptions, and our mental models of the world of others and of ourselves. Implicit memories encode our earliest forms of learning about the world. Implicit memories directly shape our here-and-now experiences without clues to their origins from past events. Attachment research, combined with the independent findings from our modern studies of genetics and developmental neurobiology, suggests that specific kinds of communication within emotionally connected relationships appear to offer the most important experiential world in which the child's mind can develop. This perhaps is best seen in ways of understanding the development of the self.

THE DEVELOPMENT OF "SELF" AND HUMAN RELATIONSHIPS

When we think about psychological development, about the developing mind, it is helpful to think about what the "psyche" actually is. There is an entity called the psyche or the mind that is as real as the brain, the heart, or the lungs, although it cannot be seen directly with or without the aid of microscopes or other tools of modern technology. One definition of the psyche is:

"1. the human soul; 2. the intellect; 3. psychiatry—the mind considered as a subjectively perceived, functional entity, based ultimately upon physical processes but with complex processes of its own: it governs the total organism and its interaction with the environment" (Webster's, 1996). Within this definition, we can see the central importance of understanding the psyche, the soul, the intellect, and the mind in understanding human development.

A number of authors have offered various views of how the sense of self can be understood. The psychiatrist and infant researcher Daniel Stern, for example, has examined the ways in which the self develops from within interpersonal relationships during the first few years of life (Stern, 1985). Antonio Damasio, a neurologist, has examined the neurological structures that subsume the manifestations of various aspects of consciousness at the root of three very different forms of self (Damasio, 1999). In my own work (Siegel, 1999), I have examined an "interpersonal neurobiology" of the sense of self as it emerges from the various layers of neural integration and forms of memory. Because the conceptualization of self is so fundamental to the notion of development, I will explore these and other perspectives in depth, and offer a new view of the connection of the sense of self to the mental/neural representation of self-with-other at the root of neural integration and developmental processes.

Stern (1985) has suggested that the self develops within stages during the first years of life. Each domain of self experience begins at a certain age but then continues to play an important role throughout the lifespan. From birth to two months, the infant's "emerging self" begins in which the body takes in sensory data and the infant has the sense of emerging organization of the world as directly experienced. From two/three months to seven to nine months, the infant has the onset of a sense of a "core self," one in which the infant's sense of agency (the center of will), coherence (sensations of the body), affectivity (emotionality), and continuity (the sense of self across time in the form of memory) are all central features. From nine months to around 18 months, the "subjective self" emerges in which there is a sense of self and self-with-other that involves the shared attention, intention, and emotion between caregiver and child. By the second birthday, the "verbal self" has begun in which words begin to be shared between self and other. Beyond this period, a "narrative self" emerges in which autobiographical narratives play a major role in defining the self (Wolf, 1990).

Damasio (1999) has suggested that various neurological studies (of normal and diseased brains) can be examined to reveal three forms of "self" and two forms of consciousness. Within deep structures in the brain that represent sensory information from the outside world (perceptions) and from the body (via the "somatosensory system") is created a "proto-self." This can be seen as a direct experience of the brain with the outer and bodily worlds. These representational processes can be called "first-order" neural maps. Within higher circuits in the brain are the neural processes that create a "second-order" map of the proto-self as it is changed by its interaction with the world/body. In other words, these higher brain regions are able to have a neural map of the proto-self before interaction and then a proto-self just following interaction with the world/body. This second-order map is in essence a neural symbol of change: it compares the proto-self before and after the interaction. This process of change defines the "core self." The ability of the brain to focus attention on the "object" that produced the change in the proto-self that created the core self—whether it is something in the world (a physical object), something in the body proper, or an image in the mind itself—creates the heightened sense of awareness Damasio calls "core consciousness." Core consciousness is a "here-and-now" experience of focused attention that is fundamentally a measure of how the proto-self is changed by interaction with an "object" in the internal or external world.

Damasio goes on to point out that a third, "higher" grouping of neural structures is essential for what he has called, "extended consciousness." Extended consciousness can be thought to involve "third-order" neural maps—neural representations of the changes in the core self over

time. (These are maps of the changes in the changes of the self in interaction with objects). Such a process allows for the brain to create an "autobiographical self" that records the history of the individual, compares it to present experience, and prepares for the future.

Other scientists have also discussed various conceptualizations of consciousness and the neural structures that subsume their function. For example, Gerald Edelman (1992) has described a primary form of consciousness that is in the "prison of the present" and a "higher form" of consciousness that depends upon language for its functioning in order to liberate the self from that "prison" in creating a sense of past and future. Ernst Tulving and colleagues (Tulving et al 1994; Wheeler, Stuss, & Tulving, 1997) have described a form of "autonoetic consciousness" that permits the self to create the experience of "mental time travel" that links past, present, and future. Within this framework there is also a sense of a "noetic consciousness," a knowing of facts without a sense of self. In many of these frameworks, consciousness is described as involving at least two distinct processes that include a "here-and-now" form of awareness that is distinct from a "past-present-future" integrating process of consciousness.

One can draw on a number of these perspectives in examining how interpersonal experiences may shape the higher, extended, autonoetic forms of consciousness. The neural substrate that allows for the sense of self that "emerges" early in life, the foundations for the emerging or proto-self, is likely to be determined in large part by genetic and constitutional features. In neurologically normal individuals there is likely a fairly similar basic mechanism involved in the creation of an emerging proto-self experience. This sense of self is rooted in the direct experience of the brain as it interacts with its environment: the external world, the body proper, and the mind itself (the neural flow of energy and information within the brain). Neurologically impaired individuals may differ significantly in the manner in which this emerging proto-self is organized and thus how the subsequent and more elaborated senses of self (core, subjective, verbal, narrative or the core and autobiographical selves) come to be formed.

Many of these views converge upon the notion, paralleled by studies of implicit memory, that the brain creates a "here-and-now" experience of self. This core ability of "living in the moment" may also have a large degree of genetically determined neural structure to it. However, as Damasio points out, one view of this core self is that it is the neural mapping of the individual's changing in response to interaction with an "object" in the external or internal world. In this manner, the core self may indeed be subject to huge degrees of impact by the environment. For example, if the environment is one of trauma and stress, the core self will be impacted to a great degree. The sense of agency, coherence, affectivity, and even continuity (memory) of the self in interaction with others will be severely impaired in cases, for example, of familial child abuse (Siegel, 1995, 1996). For these reasons, the deepest sense of self awareness, of core consciousness, may be profoundly influenced by early experiences in infancy even before explicit, autobiographical memory is available.

This neurological view of the creation of a core self experience may also help us to understand the profound importance of collaborative, contingent communication in the development of the infant, and perhaps normal functioning throughout the lifespan. Secure attachments are created within such a mutually resonant form of interpersonal communication. We can propose that the alignment of states of mind inherent in contingent communication enables the core self of each member of an interacting dyad to have a sense of "fullness": as the proto-self is changed in response to interaction with another, the contingency of the transaction within collaborative relationships enables the ever evolving core self to have a sense of coherence. Such coherence is defined by the fundamental manner in which the responses of the "other," of the "object" in the world, are directly contingent to the signals given off by the pre-change proto-self. The subsequent collaborative changes in the proto-self create a core self-experience that is coherent and inherently defined as connected to another person. In this fundamental

neural manner, interpersonal connections can be seen to create the self. When these interpersonal connections are contingent, the self becomes integrated and coherent.

One aspect of the self is that of autonoesis, or "self-knowledge," as revealed in autobiographical narratives. Attachment research has established that one of the most powerful predictors of an infant's attachment to the parent is the parent's autobiographical narrative coherence (Hesse, 1999). Narrative coherence can be examined by determining the free and flexible flow of information as individuals tell the story of their lives, beginning with the memories they recall of their earliest experiences. The research instrument utilized to assess this coherence is the Adult Attachment Interview (see Hesse, 1999; Main, 1995). The Interview is a narrative review by the parent of her recollections of her earliest relationship experiences with her own parents. One can view such autobiographical accounts as revealing the capacity of the mind to achieve a certain amount of integration of functioning. Such a process can be called "coherent autonoesis." This integration appears to allow the individual to have an internal sense of connection to the past, to live fully and mindfully in the present, and to prepare for the future as informed by the past and the present. In this manner, coherent autonoesis allows for the fluid flow of past, present, and future. Such fluid and flexible reflections on the past, present, and future are the hallmark of coherent autobiographical narratives.

But why should such a coherent self-reflective process of the parent be associated with the child's security of attachment? This question has been one of the essential issues in attachment research that I have tried to address in *The Developing Mind* (Siegel, 1999). In the next section, I will offer some possible links between the internal processes of autonoesis and the interpersonal connections of parent–child relationships.

ATTACHMENT AND THE DEVELOPING MIND

Longitudinal attachment studies have found that securely attached children appear to have a number of positive outcomes in their development (Cassidy & Shaver, 1999). These include enhanced emotional flexibility, social functioning, and cognitive abilities. Some studies suggest that security of attachment conveys a form of resilience in the face of future adversity. In contrast, a number of studies suggest that the various forms of insecurity of attachment can be associated with emotional rigidity, difficulty in social relationships, impairments in attention, difficulty in understanding the minds of others, and risk in the face of stressful situations. Suboptimal attachment experiences may predispose a child to psychological vulnerability in part by altering the brain's neuroendocrine response to stress (Liu et al., 1997; Rosenblum, Coplan, Freidman, Basoff, Gorman, & Andrews, 1994).

One form of insecurity of attachment, called "disorganized/disoriented," has been associated with marked impairments in the emotional, social, and cognitive domains. Individuals with this form of attachment have also been demonstrated to have a predisposition toward the clinical condition of dissociation in which the capacity to function in an organized, coherent manner is at times impaired (Carlson, 1998; Liotti, 1992; Main & Morgan, 1996; Ogawa, Sroufe, Weinfeld, Carlson, & Egeland, 1997). Recent studies have also found that youths with a history of disorganized attachments are at great risk of expressing hostility with their peers and have the potential for interpersonal violence as they mature (Lyons-Ruth, Alpern, Repacholi, 1993; Lyons-Ruth & Jacobwitz, 1999). This disorganized form of attachment has been proposed to be associated with the caregiver's frightened, frightening, or disoriented behavior with the child (Main & Hesse, 1990). The parents of these children often have an Adult Attachment Interview finding of "unresolved trauma or grief" that appears as a disorientation in their narrative account of their own childhoods (Hesse, 1999). What this implies is that the lack of resolution of trauma or loss in a parent can lead to parental behaviors that create

"paradoxical," unsolvable, and problematic situations for the child. The attachment figure is intended to be the source of joy, connection, and emotional soothing. Instead, the experience of the child who develops a disorganized attachment is such that the caregiver is actually the source of alarm, fear, and terror, so the child cannot turn to the attachment figure to be soothed (Main & Hesse, 1990).

This finding provides important insights into the nature of the transmission of trauma across the generations. Helping such individuals resolve their traumatic experiences and losses may be an important therapeutic intervention in attempting to alter the course of devastation that such transgenerational trauma can create.

These and numerous other findings suggest that the patterns of communication between caregiver and infant provide a foundation for the developing mind of the child. What are the essential ingredients of secure attachments, then, and how can we understand their importance in the developing child's life?

We can summarize several basic elements of interpersonal relationships that are likely to foster emotional well-being and psychological resilience. Although derived from research studies in attachment, these ideas may also be useful for understanding the impact of close, interpersonal relationships of all sorts throughout the lifespan.

Parents are usually the primary attachment figures for a child. For a variety of reasons, in many families there may be a decreased availability of parents to care for their young children during the working hours. This situation requires that we address the basic needs of the young child to have the opportunity to develop secure attachments with caring, consistent, and reflective adults in addition to her own parents. Fortunately, the infant's mind appears to be quite capable of creating a secure attachment to a selective few adults besides the parents. Grandparents and other relatives, daycare providers, nannies, and other individuals who are "caregivers" for a child may all play important roles as attachment figures. Understanding a child's individual needs and style of communicating, taking joy in the child, and being able to soothe the child when he is in distress, are each basic components of the child's relationship with the attachment figure. The following are five basic elements of how caregivers can foster a secure attachment in the children under their care.

1. *Collaboration.* Secure relationships are based on collaborative, contingent communication. The signals sent by each member of an attuned dyad (a pair of individuals) are directly responsive in quality and timing with each other. These attuned communications often have their foundation in the nonverbal signals that are shared between two individuals. Eye contact, facial expression, tone of voice, bodily gestures and timing and intensity of response are all fundamental aspects of nonverbal signals. The sharing of nonverbal signals creates a joining of two minds at a basic level of "primary" emotions. As discussed later in this article, these primary emotions can be seen as the "music of the mind," and thus the sharing of these nonverbal signals, the sharing of the primary states of mind of each person, creates a resonant connection that often may have a sense of emerging vitality. Each person may come to "feel felt" by the other. Some adults may find such joining experiences exhilarating and easy to create; others may find them uncomfortable or unfamiliar, and be unable to participate in such an intimate "connecting" experience. Children need such joining experiences because they provide the emotional nourishment that developing minds require. Relationships that are "connecting" and allow for collaboration appear to offer children a wealth of interpersonal closeness that supports the development of many domains, including social, emotional, and cognitive functioning. Such collaboration may be essential in the creation of a coherent core and autobiographical sense of self.

2. *Reflective Dialogue.* Secure attachment relationships may involve the verbal sharing of a focus on the internal experience of each member of the dyad. Attachment figures recognize the signals sent by the child, attempt to make sense of them in their own minds, and then communicate to the child in such a manner that creates "meaning" for the child in the shared dialogue about the mental states of the child and of the caregiver. Internal experience, or "states of mind," can involve emotions, perceptions, thoughts, intentions, memories, ideas, beliefs, and attitudes. By directly focusing on these aspects of mental life, the adult can create a sense that subjective experience is both important and can be communicated and shared. In this manner, the "mind" itself becomes a central focus of sharing in the discussions between two minds. Such a meaning-making process coupled with collaborative, reciprocal communication allows the child to develop "mindsight": the capacity of the mind to create the representation of the mind of others, and of the self (Siegel, 1999).
3. *Repair.* When attuned communication is disrupted, as it inevitably will be, repair of the rupture is an important part of reestablishing the connection within the dyad. Repair is healing. Repair is also important in helping to teach the child that life is filled with inevitable moments of misunderstandings and missed connections that can be identified and connection created again. Such interactive repair allows the child to make sense of periods of painful disconnection and create a sense of meaning out of the understanding of one's own and another's mind. An adult's pride may at times inhibit repair and leave the child isolated in what may be a shameful state of disconnection. Intense uncomfortable emotional states in the child or parent may lead to a disconnection in collaborative communication. Prolonged disconnection, especially if combined with hostility and humiliation, can have significant negative effects on a child's developing senses of self. Providing repair of the inevitable disconnections of attuned communication can occur naturally in a setting where parents and other attachment figures generally provide consistent, predictable, reflective, intentional, and mindful caregiving.
4. *Coherent Narratives.* The connection of the past, present, and future is one of the central processes of the mind in the creation of the autobiographical form of self-awareness. An adult without a coherent autonoetic process may be at risk of providing interactive experiences for a child that produce various forms of insecure attachment. In essence, adults with a flexible capacity to integrate their experiences across time appear to also be able to provide integrating interpersonal communication with their children. In addition, adults can teach children about the world of the self and of others by joining with them in the coconstruction of stories about life events. These stories focus on activities as well as the mental life of the characters. In so doing, the adult is both collaborating in the construction of reality for the child, as well as giving her the very tools she needs to make sense of the internal and external worlds in which we all live.
5. *Emotional Communication.* Attachment figures can amplify and share in the positive, joyful experience of living. These heightened moments of sharing a sense of vitality are important in creating the foundation for a positive attitude toward the self and others. Equally important is the attachment figure's ability to remain connected to the child during moments of uncomfortable emotion. Thus, negative emotional states can be shared as the adult then helps the child to reduce these states and soothe his distress. Helping a child learn that he will not be emotionally abandoned during these moments and that he can learn to understand and soothe his painful emotional state is an important role for the attachment figure to play. Adults also need to be sensitive to a child's cycling needs for direct connection and for solitude. Awareness and respect for these

changing needs for connection are a part of emotionally attuned communication. These interactive forms of emotional communication may be at the core of how interpersonal relationships help to shape the ongoing emotional and social development of the child's growing mind.

EMOTION

Emotional communication is at the heart of attachment. But what exactly is emotion? It may be surprising that both clinicians and academicians often have quite varied responses to this question. Exploring the nature of emotion as a fundamental process both of the individual and of interpersonal communication may help deepen our view of an "interpersonal neurobiology" of the developing mind. Researchers have examined a number of ways to view emotion. For example, emotion can be conceptualized as an integrating process in the mind with many dimensions (Ciompi, 1991). Some scientists argue that emotions are everywhere in the processes of the mind, while others support very specific circuits in the brain that mediate emotion (see LeDoux, 1996). In general, emotion is considered to be a central process that interconnects many aspects of mental functioning. This perspective is expressed by Kenneth Dodge: ". . . all information processing is emotional, in that emotion is the energy that drives, organizes, amplifies, and attenuates cognitive activity and in turn is the experience and expression of this activity" (Dodge, 1991, p. 159).

What are these processes, these emotions, and how can we "see" them at work? The study of emotion suggests that nonverbal behavior is a primary mode in which emotion is communicated. Facial expression, eye gaze, tone of voice, bodily gestures, and the timing and intensity of response each are fundamental to emotional messages (Ekman, 1992). But what exactly is emotion? We can know when others are upset and "emotional," but what does this really mean? Attempting to clearly define the process of emotion and its regulation can yield some helpful ways of understanding the mind, how the mind arises from the processes of the brain, and how one mind interacts with other minds within human relationships. Examining the fundamental ways in which emotion is an integrative process can enable us to see how central emotion is in both intraindividual mental processes and in interpersonal communication.

As Damasio notes:

> It would not be possible to discuss the integrative aspects of brain function without considering the operations that arise in large-scale neural systems; and it would be unreasonable not to single out emotion among the critical integrative components arising in that level. Yet, throughout the twentieth century, the integrated brain and mind have often been discussed with hardly any acknowledgment that emotion does exist, let alone that it is an important function and that understanding its neural underpinnings is of great advantage. (Damasio, 1998, p. 83)

It is for this reason that we need to expand the area of "affective neuroscience" if we are to meaningfully explore the neurobiological basis of interpersonal relationships, subjective experience, and the developing mind. In essence, we need to build on the "objective" approaches of science to provide the foundation for understanding why interpersonal relationships (such as attachment) that focus on the importance of the "subjective" experience of each individual are most likely to promote emotional well-being and psychological resilience. At the core of these mental phenomena is the process of integration.

Attachment relationships differ across the various categories in the ways in which states

of mind and emotional communication are shared between parent and child (Siegel, 1999). Distinct patterns of emotional communication characterize each of the differing attachment classifications. The emotional processes of the more mature adult mind can be used by the child to regulate her own internal state. From the beginning of life, "self-regulation" is actually determined in part by an interactive "dyadic" process of mutual coregulation (Feldman, Greenbaum, & Yirmiya,1999; Hofer, 1994; Sroufe, 1996). A child uses the state of mind of the parent to help organize her own mental processes. This alignment of states of mind permits the child to regulate her own state by direct connection with that of her parent. The processes of affect attunement and social referencing reveal the fundamental way in which nonverbal communication is the medium in which states are aligned. What do these nonverbal signals actually represent?

One way of answering this question is by viewing emotion as the fundamental process that regulates the flow of energy and information. In this manner, I have proposed (1999) that a "primary" emotional process occurs that includes initial orientation, appraisal, and arousal. Subsequent elaborative mechanisms lead to differentiated emotional states (such as the categorical emotions of sadness, joy, anger, fear). Within this framework, the flow of energy is directed within a primary emotional process that leads to characteristic profiles of energy activation. These profiles can be seen externally as what Stern (1985) has termed, "vitality affects" and can be experienced internally parallel to what Damasio (1999) has called "background" emotions. These reflections of primary emotional states are the shared focus within "affective attunements." By directing the flow of energy and information processing within the brain, primary emotions reflect a core process that interconnects processes within one mind, as well as connecting those of one mind to those of another.

This integrative and interpersonal view of emotion is one perspective on emotion and brain functioning. Within the field of neuroscience, there is actually a heated debate about the nature of emotion in the brain. For example, for many decades there was an accepted viewpoint that emotions emanated from a part of the brain called the limbic system. Research paradigms attempted to carefully define the boundaries and specific functions of this system but often were unable to identify its functional limits (LeDoux, 1996). The essential point here is that emotion is *not* limited to some specifically designed circuits of the brain that were once thought to be the center of emotion. Instead, these same "limbic" regions appear to have wide ranging effects on most aspects of brain function and mental processes. Emotion is perhaps better seen as an integrative process throughout the brain, rather than some element limited to one particular area. The limbic regions, however, are specialized to carry out the appraisal of meaning or value of stimuli. They are also dominant for the information processing system that carries out social cognition, including face recognition, affiliation, and theory of mind (the view that another person has a subjective experience of mind) (Barbas, 1995; Baron-Cohen, 1995; Baron-Cohen & Ring, 1994; Davidson, 1992; Halgren, 1992; Haxby et al., 1996, Panskepp, 1982; Rolls, 1995; Ross et al., 1994; Tucker, 1992; Watt, 1998). In this manner, we can see a convergence between social processing and the creation of meaning within emotional processing.

Within the field of developmental psychology and psychopathology, emotion and emotion regulation are seen as a part of the same process (Cicchetti, & Rogosch, 1997a; Cicchetti & Tucker, 1994; Fox, 1994; Garber & Dodge, 1991). Emotions are both regulated and perform regulatory functions. This view describes both the omnipresent nature of emotion and the way in which the distinction sometimes made between cognition and emotion, thoughts and feelings, is artificial, and can potentially impair our efforts to understand mental processes.

Emotion involves complex layers of processes that are in transaction with the environment. These transactions involve cognitive processes (such as appraisal or the evaluation of meaning) and physical changes (such as endocrine, autonomic, and physiological). As Alan Sroufe has

described, emotions involve "a subjective reaction to a salient event, characterized by physiological, experiential and overt behavioral change" (Sroufe, 1996, p. 15). A similar view suggests that emotion can be seen as involving neurobiological, experiential, and expressive components (Izard & Kobak, 1991).

Emotions represent a dynamic process in which they are created within the socially influenced value appraising processes of the brain. Emotion is integrative in that it is a process that connects other processes to each other. By viewing emotion as central to the regulation of energy and information flow in the brain, we can see that emotion plays a central role in creating and regulating mental life. In this manner our understanding of the distinct ways in which emotion is experienced and is communicated among individuals can shed light on how the mind develops and functions within the social context of human relationships.

INTERPERSONAL COMMUNICATION AND THE DEVELOPMENT OF MINDSIGHT

The mind of the child appears to develop a core manner in which the mental states of other individuals become represented within the neural functioning of the brain (Stone, Baron-Cohen, & Knight, 1998). In the child's early life, emotional interactions with attachment figures appear to be of primary importance in shaping the core (here-and-now) and autobiographical (past-present-future) senses of self. We can see such interactive effects in the central ways in which the brain creates neural maps of the self as influenced by the "object." These neural maps are the essence of how the brain constructs its specific experiences of reality.

One form of neural map is the way in which the brain creates images of other minds. I have used the term "mindsight" to refer to this representational process. In essence, this is the capacity of one mind to "perceive" or create representations of the mind of oneself or of another (Aitken & Trevarthen, 1997). The basic elements of mind that are "seen" can include thoughts, feelings, perceptions, beliefs, attitudes, intentions, and memories. Such a complex capacity develops throughout childhood, and can become continually more enriched throughout the lifespan. Other authors have described similar processes using terms such as mentalizing, reflective function, theory of mind, and social cognition (Fonagy & Target, 1997). In some neurologically impaired individuals, the capacity for mindsight may be disturbed, such as in children with the disorder of autism (Baron-Cohen, 1995). In some cases of intrusive parenting, children also have been shown to have diminished mentalizing abilities (Fonagy & Target, 1997). This suggests that the capacity for mindsight develops from within the intact neurological structures of an individual who experiences a certain degree of collaborative, nonintrusive attachments.

In exploring the fundamental neural substrate for the elements that allow the brain to create maps of other minds, it has been helpful to examine the nature of the early interpersonal communication and the neurobiology of the largest systems of the brain, the left and right hemispheres, and how they may each develop and come to function in an integrated manner (Springer & Deutsch, 1993). From the embryonic period onward, there is a significant asymmetry in the nervous system. The "higher" functions of the brain, those of more complex and abstract thinking, are directly shaped by the motivational forces of the "lower" areas of the same side of the brain (Trevarthen, 1996; Tucker, Luu, & Pribram, 1995). The left and right sides of the entire brain appear to be driven by different "streams" of processing or neural circuits that create distinct flows of information that drive subsequent information processing in particular directions.

The left and right sides of the brain are anatomically isolated except for connections made directly through bands of neural tissue called the corpus callosum and the anterior commissures

(Trevarthen, 1990) that develop during the first decade of life. Indirect passage of information may occur at other sites, including an area called the cerebellum. Of note is that early child abuse has been shown to impair the development of the corpus callosum, as well as leading to a diminished development of the brain as a whole (DeBellis et al., 1999a, 1999b). Severe stress is toxic for the growing brain.

In general, a wide array of studies in humans suggest that the isolated functions of the left and right hemispheres may be "integrated" under normal conditions in creating the mind. The complex capacity for mindsight, for example, appears to require the integration of aspects of both right and left hemisphere functioning (Stone et al., 1998). Thus, we normally experience a blending of right and left functions. However, the anatomical separateness of these two hemispheres also permits for functional isolation under certain conditions. Such isolation of function between, or within, hemispheres may produce a "nonintegrated" functioning and the impairment of certain intricate mental processes. Dissociation may be one clinical syndrome that reflects this mental disassociation of processes (Siegel, 1996).

The right hemisphere is involved in more self-soothing actions in the infant, has a more integrated mapping of the "somatosensory system" (the representation of the body in the brain), directly regulates bodily processes, is involved in affective expression and perception, specializes in the processing of perceptual images, mediates autobiographical recollection, and processes information in a "holistic" manner. The capacity for mindsight may depend, in large part, on the integration of a number of these bodily, emotional, and social information processing circuits that reside predominantly in the right side of the brain and how they become interconnected with those of the left hemisphere.

The left side of the brain is involved in more exploratory actions in the infant, has very little integrated representation or regulation of the body, and is not very good at reading the nonverbal expressions of emotions of others. The left side of the brain has a primarily linguistic processing mode, and processes information using "syllogistic reasoning"—looking for cause–effect relationships in a linear, logical fashion. The left hemisphere is said to have an "interpreter" function, attempting to use the limited bits of information at its disposal to assess true/false distinctions and determine causal relationships within linear, logical, narrative descriptions.

In this manner, one can see that some attachment figures provide children with "nonintegrated" communications that serve to impair the movement of the child toward integration of his or her own experience. One view is that certain parents may isolate their verbal output from their emotional facial and tone of voice expressions (Beebee & Lachman, 1994). I have proposed a way to understand how these nonintegrated attachment experiences impact upon the growing brain of the child (Siegel, 1999). The right hemisphere is the dominant side of the brain during the first few years of the infant's life (Chiron, Jambaque, Nabbot, Lounes, Syrota, & Dulac, 1997). "Dominance" means that the right hemisphere is both growing more rapidly and is more active (Thatcher, 1997). In fact, areas of the right hemisphere within the prefrontal cortex (the orbitofrontal region, just behind and above the orbits of the eyes) that regulate bodily function and emotionally attuned communication appear to be actively developing during this period (Schore, 1994, 1996). Thus, the ways in which the caregiver comes to communicate with the infant during these crucial early years may help shape the right hemisphere's capacity for self-regulation, self-other relationships, an autobiographical sense of self, and the basic elements of the capacity for mindsight. These can all be seen as complex functions that depend upon various dimensions of neural integration.

Recent work also suggests that the prefrontal regions of the brain may also be a part of the integrated circuitry that permits social and moral behavior (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999; Dolan, 1999). In these reported cases of early neurological damage

to this important area of the brain, individuals were found to have marked impairments in both their capacity to understand basic social information and to behave in socially and morally meaningful ways. What we do not yet know is exactly how certain early adverse experiences in a child's life may negatively shape the development of the complex circuitry, including that of the prefrontal regions, that has been proposed to permit social and moral behaviors. Neuroscience is just beginning to discover the details about a possible neurological origin of "conscience." Our work in attachment will benefit from these independent findings in examining how secure relationships may promote moral development through the impact of interpersonal relationships on neural structures.

What we do know from the independent field of studies in child development is that certain attachment experiences appear to promote socially adaptive, morally responsible behaviors in children. One way of thinking about these secure attachments is that they involve the basic elements discussed earlier, and have as their foundation the ability of the adult to create a collaborative form of communication with the child. But how can a logical, word-oriented adult communicate with a primarily right-hemisphere dominant nonverbal infant to help with the earliest stages of the development of these important functions? The nonverbal interactions of caregiver and infant can be proposed to be the most important elements that help to create a secure attachment between the infant and the caregiver at the beginning of life. As the child grows, as discussed above, reflective dialogues that help create meaning and interpret the complex world of human minds for the child are extremely important. Such reflective, meaning-making dialogues require, we can propose, an integrated right and left hemisphere in both caregiver and child. But adults often live in a logical world filled with word-dominated thoughts. These left-hemisphere processes are often far from the more subtle, nonverbal experiences that the adult needs to be able to share with the infant. In essence, the infant's brain needs to "feel felt" by the caregiver. Such a feeling of connection, in fact, may be extremely important for each of us in our relationships throughout the lifespan. Collaborative communication is far more than the sharing of linguistic packets of verbally understood words.

At the neurological level, such a nonverbal, emotional sharing involves the output of the right hemisphere of each member of the interacting pair. As the right hemisphere both sends and receives these signals, the opportunity is created for a "resonance" of the minds of each of the individuals. At this nonverbal, core self-level, the interaction of self with other becomes mapped in the brain in a manner that literally, neurologically, creates the mind of the other. In Stern and in Damasio's terms, we can propose that the emerging proto-self takes in the signals from the caregiver and maps the changes in the proto-self in response to these nonverbal signals. These signals are "the object" that produces the changes in the proto-self, and thus, are themselves woven directly into the construction of the core self. The core self is the second-order neural mapping of the changed proto-self as core consciousness focuses attention on the "object"—the caregiver's face, eye gaze, tone of voice, and gestures.

We can propose that within the child's brain is created a multisensory image of the emerging caregiver's nonverbal signals. These nonverbal signals reveal the primary emotional states of the individual's mind. These primary emotions, the music of the mind, are the most direct way in which the nonverbal, subjective state of one's current mental processing can be externally expressed to another person. Such primary emotions are the profiles of activation, the flows of energy and nonverbal information, that reveal the primary essence of one's mind. It is in this manner that emotionally attuned communication, the resonant sharing of nonverbal signals, allows for the child to "feel felt" and to create a secure attachment with that connecting adult. It is the sharing of these nonverbal expressions of primary emotions that allows for the most direct connection of one mind to another. Within such attuned, collaborative experiences the securely attached child's core self is then able to reflect a coherence between the self and

the "other." This defining focus of the self as a "self-with-attuned-other" is, I believe, the developmental origins of our natural capacity for caring about and feeling connected to others in the world.

The heart of the emotional transactions with the growing child can be described as being the sharing and amplification of positive emotional states, and the sharing and reduction of negative states. These repeated and reliable emotional transactions allow a child to feel connected in the world. It is also these communications that allow a child to initially rely on the caregiver for help in regulating her own emotions, and then later to develop a more autonomous form of flexible self-regulation. In this manner attuned emotional communication within secure attachments leads to a healthy and flexible capacity for self-regulation.

COMPLEXITY, COHERENT NARRATIVES, AND NEURAL INTEGRATION

To understand the links among interpersonal communication, personal narratives, and self-regulation, it is helpful to examine the experience of mind from the perspective of complex systems. The application of "complexity theory" or the "nonlinear dynamics of complex systems" to the human mind has been useful in understanding the processes of development and of human experience (Cicchetti & Rogosch, 1997b; Fogel, Lyra, & Valsiner, 1997; Globus & Arapia, 1993; Lewis, 1995, 1997; Robertson & Combs, 1995; Thelen, 1989). Complexity theory examines the ways in which the flow of the states of activation of a system has self-organizational properties, movement toward maximizing complexity, and recursive, self-reinforcing processes. Application of these principles to the layers of systems, from neural circuits to interpersonal relationships, can provide useful insights into the bridges across these levels of analysis.

Development can be seen as a movement toward ever more complex states of processing over the lifespan (Thelen, 1989). In this manner, the brain as a complex system may be naturally capable of attaining states of connection within its own neural circuits that allow it to achieve greater and greater degrees of integrated functioning. Such integration—the clustering of distinct, differentiated components into a functional whole—can be seen as allowing the brain to achieve these higher states of complexity. Complexity can be viewed as a flow of states of activation that move between the extremes of sameness, order, and rigidity on one side, and variation, randomness, and chaos on the other. The flow of states between order and chaos creates the maximal complexity of a system. The key element in attaining such complexity within a system's changing states is the combining of differentiation (component parts being distinct and well-developed in their own uniqueness) with integration (clustering into a functional whole). Making component parts identical—sameness and order of the system—may create a form of integration, but the elimination of the unique elements of differentiation actually decreases the level of complexity achievable by the system. Having component parts of a system activated in total isolation from each other—randomness and chaos of the system—may permit differentiation but lacks the integration necessary to achieve complexity.

Human relationships may involve these principles of complexity. Secure attachments enable resonant interpersonal connections in that they foster the blend of differentiation of each individual with the integration of each person within collaborative, contingent forms of emotional communication. In this manner, we can see that human relationships that encourage both individual differences (differentiation), and interpersonal collaboration (integration) may nurture the most complex states. Nonlinear dynamics suggests that systems that move toward such complexity are in fact the most stable, flexibly adaptive, and capable of a wide range of "self-organizing" processes. Within secure attachments, such self-organization may be seen as the

ultimate gift that caregivers offer to their children: to enable the self to achieve differentiation and integration in acquiring flexible and adaptive means for self-regulation. Such an ongoing process involves the internal adjustment of mental functions as well as the continual modification of interpersonal connections. This capacity to modify both the internal and the external (interpersonal) dimensions of connections may be at the heart of mental health and emotional well-being.

The linkage of secure attachment, the development of mindsight, and the integrating role of nonverbal and verbal processing can also help us to explore the possible connections between coherent autonoesis and collaborative interpersonal relationships. In a fundamental way, both are about the interconnectedness of life. Each also involves the process of neural integration. The processes of coherent self-knowledge and of collaborative interpersonal communication each appear to be mediated by the same integrating prefrontal region. This region and these processes are fundamentally involved in connecting widely distributed and differentiated functions into a coherent whole. They thus involve integration at both the intra- and interpersonal level of organization.

From the beginning of development, the brain has the capacity to differentiate its circuitry and also to integrate its functioning. This blend of differentiation and integration within the single brain also applies to the nature of the development of the child within interpersonal relationships. From the beginning, the brain is capable of—and, in fact, is hard-wired to—make connections with other brains. As we have seen, the core self evolves in the response of the emerging proto-self in interactions with objects, including others in the world. As the more complex capacity for autonoesis develops and creates an autobiographical self, these third-order neural maps are built on the second- and first-order mappings of the self in interaction with others in the world. In this fundamental way, the manner in which we come to construct our integration of past-present-future is built upon the self in interaction with other selves. This is the way in which the collaborative communication of attachment relationships directly shapes the development of the self.

The contingent, collaborative communication of secure attachments produces a coherence within the here-and-now core self as well as in the past-present-future integrating autobiographical self. In this manner, coherent interpersonal relationships produce coherent neural integration within the child that is at the root of adaptive "self-regulation."

A parent with a flexible access to an integrating process that enables self-regulation would likely be more emotionally accessible to the range of states and signals provided by a child. Attachment research suggests that we learn different adaptive strategies early in life for communicating with other individuals. "Integration" can be proposed to be a central self-organizing mechanism that links the seemingly disparate aspects of emotion, narrative, and interpersonal relationships within the human mind. The "wholeness" of this integrative process can be described within the concept of "coherence" in which the disparate elements contribute to the flow of a system toward maximal complexity. Within this adaptive and flexible flow of states, individual components remain highly differentiated AND functionally united. Coherent narratives may reflect such an integrative process within the mind. Interpersonal integration can be seen when the mind of one person has the free flow of energy and information with another mind. Such adaptive and flexible states flow between regularity, sameness, and predictability on one side and novelty, change, and uncertainty on the other. This flow of states yields a maximal degree of complexity. Such dyadic states may be seen within securely attached children and their parents.

The structure of the narrative process itself may also reveal the central role of integration in states of mental health and emotional resilience. Within the brain, the neural integration of the processes dominant in the left hemisphere with those dominant in the right can be proposed

to produce a "bihemispheric" coherence that enables many functions to occur. The left hemisphere functions as what has been called an "interpreter," searching for cause–effect relationships in a linear, logical mode of cognition. The right hemisphere is thought to mediate autonoetic consciousness and the retrieval of autobiographical memory. Also dominant on the right side are elements of the mindsight module of information processing. Coherent narratives can thus be proposed to be a product of the integration of left and right hemisphere processes: the drive to explain cause–effect relationships (left) and to understand the minds of others and of the self within autonoetic consciousness (right). In this manner, we can propose that coherent narratives reflect the mind's ability to integrate its processes across time and across the representational processes of both hemispheres. Could this integrative capacity have more generalized functions, enabling that same individual to then create a "coherent dyadic state?" Is this central process of the mind's capacity for integration—both internal and interpersonal—the link between narrative and parent–child relationships? Perhaps such a capacity is at the heart of secure attachments.

We can propose that the brain is structured with an innate capacity to transcend the boundaries of the skin of its own body in integrating itself with the world, especially the world of other brains. This linkage permits mindsight and creates the capacity for compassion. Under certain situations, the neurological foundations for mindsight may be compromised and the sense of integration with others may be impaired. With some neurological conditions, such as sensory impairment, caregivers may be especially challenged to provide the kind of connecting, collaborative communication that allows the child to "feel felt," make sense of the internal world of minds, and create the capacity for mindsight. In other situations, suboptimal caregiving may not have fostered the development of a coherent sense of a core or autobiographical self. We can view these situations as being the inadequate development of a coherent sense of another's mind within the mind of the child. Such interactions are "incoherent," and fail to facilitate the child's own integrative processes. The fundamental outcome of such nonintegrative states can be seen as an impairment in self-regulation.

UNRESOLVED STATES, DISORGANIZED ATTACHMENT, AND IMPAIRMENTS TO INTEGRATION

One form of impaired integration and self-regulation can be seen within the minds of those individuals with unresolved trauma or grief. In this situation, we can propose, the mind has been unable to integrate various aspects of the overwhelming experiences of trauma or loss. With this unresolved condition, an adult's mind may be vulnerable to entering "altered states" in interaction with others, especially with children. These states may be considered "lower-mode states" (Siegel, 1999) in which the functioning of the integrating prefrontal regions becomes temporarily impaired and behavioral output is driven more by the emotional states and impulses of the lower regions of the brain without the more reflective, rational processes of the higher, neocortical inputs. In this "low-road" state, the caregiver may be more likely to offer the child the frightened, frightening, or disorganizing interactions that have been proposed by Main and Hesse (1990) to be at the root of disorganized attachments.

The term "response flexibility" (Siegel, 1999) can be used to describe an important integrative process mediated by the orbitofrontal region of the prefrontal cortex. Response flexibility refers to the capacity of the brain to respond to changes in the internal or external environment with a flexibly adaptive range of behavioral or cognitive responses. A number of studies point to the central role of the orbitofrontal region in carrying out such a capacity (Mesulam, 1998; Nobre et al., 1999). One can propose that this ability requires the integrative

capacities of the orbitofrontal region to functionally link elements from widely distributed input and output circuits. This region is uniquely positioned to link the major regions of the brain, including the associational cortex, limbic circuits, and brain stem areas. In this manner, the orbitofrontal region enables the more complex "higher order" abstract processing of the neocortex to be integrated with the "lower order" somatic and emotional functions of the deeper structures. Autonoetic consciousness may reveal one example of this "higher mode" of integrative processing, one that permits mental time travel and a deep sense of self awareness.

One extension of this view is that the mind is capable of a mode of information processing that does not involve the higher mode of processing. In this "lower-mode" or "low-road" processing state, response flexibility is suspended along with other integrative functions such as autonoetic consciousness and impulse control. In this lower mode, behaviors become reflexive, and the mind becomes filled with deeply engrained, inflexible patterns of response. In such a condition, emotions may flood the mind and make rational thought and mindful behavior quite impaired. We can propose that one aspect of unresolved trauma or grief is to make such a lower mode of processing more likely to occur. Although each of us may be vulnerable to entering such low-road states, unresolved conditions may make entry into these states more frequent, more intense, and more likely to occur with minimal provocation. Recovery from such states may also be especially difficult in unresolved traumatic conditions. In this situation, the individual may remain "on the low road" for more extended periods of time as well as with increased frequency.

Entry into such lower-mode states may produce excessive emotional reactions, inner turmoil, dread, or terror, as well as an ensuing sense of shame and humiliation. In such conditions, the individual may be prone to "infantile rage" and aggressive, intrusive, or outright violent behavior. The entry into such states directly impairs the capacity of the individual to maintain collaborative communication with others. In this way, the tendency to have an impairment in response flexibility and autonoetic consciousness within lower mode states may be at the core of how parents with unresolved trauma engage in the frightened and/or frightening behaviors that lead to disorganized attachment in their offspring. Lower-mode states do not allow for the sensitive, contingent communication that secure attachments require. This may be the core feature of the transfer of trauma and its devastating ripple effects across the generations.

Unresolved trauma or grief, as revealed in the Unresolved/Disorganized category of the Adult Attachment Interview, can thus be proposed to reveal a fundamental lack of neural integration within the adult's brain. The process of resolution may involve the achievement of a more integrated form of functioning that makes these lower-mode states less likely to occur. During the resolution process, if such disconnected experiences do continue, we would anticipate that the adult would be more readily able to identify them and carry out the essential interactive repair that secure attachments require. As psychotherapeutic interventions promote neural integration, we can imagine that the integrative prefrontal region may become more actively involved in the global functioning of the individual. Resolution would involve the repair of impediments to flexible self-regulation and coherent autonoesis.

Lack of resolution implies a blockage in the flow of information and energy both within the mind and between minds. One example of the failure to achieve integration is in the various forms of dissociation that may accompany lack of resolution. For example, unresolved states may involve the intrusion of elements of implicit memory in the absence of an explicit memory counterpart for past traumatic experiences (Siegel, 1996). Such "disassociations" of mental processes may be at the core of clinical "dissociation" and an outcome of both trauma and earlier histories of disorganized attachments. Lack of resolution also means the blockage in the flow of energy and information between two minds: such impairment may be a central feature of disorganized attachments. In this manner, we can see that impaired internal integration may

lead to impaired interpersonal integration.

One can see that the general approach to psychotherapy for individuals with unresolved trauma and grief would be to attempt to enhance the mind's innate tendency to move toward integration, both within the brain and within interpersonal relationships. The caregiver's ability to engage in attuned, collaborative communication will be greatly enhanced through the resolution process. Therapeutic improvement would be revealed as a more adaptive flexibility of the mind to respond to changes in both the external and internal worlds. An increased capacity to experience a broader range and higher intensity of emotion would emerge, with the caregiver becoming more able to connect with the child on a nonverbal, emotional level. Overall, these changes would reflect not only the freedom from a disorganized sense of self across time as revealed in intrusive shifts in states of mind during lived daily life and within autobiographical reflections, but also the enhanced capacity of the individual to achieve integration (internal and interpersonal) and thus more adaptive and flexible self-regulation.

REFLECTIONS ON INTEGRATION AND MENTAL HEALTH

The finding that the coherence of the adult's autobiographical narrative is the most robust predictor of the child's attachment with the parent can help us shed light on the importance of neural integration for both mental health and nurturing interpersonal relationships. Coherent narratives can be seen to reflect the ability of the "interpreting" left hemisphere to utilize the autobiographical, mentalizing, and primary emotional processes of the right hemisphere in the production of "coherent" autonoesis, or self-knowledge. The capacity to achieve such internal coherence may reveal that individual's ability to allow for the maximal complexity to be achieved within an interhemispheric form of integration within the brain. In this manner, the spontaneous, free flow of information and energy between both of the parent's hemispheres reflects a core process of integration that enables coherent autonoesis. Such bilateral hemispheric integration may also permit them to engage in the spontaneous dyadic communication that is the hallmark of secure attachments. Such attuned and reflective relationships rely on the spontaneous access to the representational processes of both the nonverbal and verbal hemispheres of the brain. Parents who can achieve such internal resonance—revealed within their coherent autobiographical narratives—will be more likely to nurture the development of such integrative processing through their attuned and reflective interactions with their own children.

The process of integration under normal conditions may yield states of activation that are more adaptive, flexible, and stable over time than nonintegrated, less complex states. As interpersonal experiences early in life shape the manner in which the child develops self-regulatory capacities, attachment patterns may instill characteristic modes of self-organization and interpersonal relatedness. Why would moment-to-moment interactions lead to lasting integrative tendencies within the child? The finding that neural systems have recursively reinforcing processes may help to understand this finding (van Ooyen & van Pelt, 1994). Neural circuits that achieve a certain degree of complexity in their structure and function appear to have self-reinforcing qualities that maintain this level of complex processing. The activation of specific patterns of neuronal firing not only creates mental representations, but it also influences the nature of the complexity that the neural networks are able to achieve. Thus, integrative interpersonal interactions may produce linkages among neural networks that reinforce their very nature. It is in this way that interpersonal communication may facilitate a direct effect on the organization of the complexity of neural structure.

The communication of emotion can be seen at the core of the interpersonal communication that facilitates integration and the maximizing of complexity. Such interpersonal sharing of

primary emotional states can be conceptualized as a form of "resonance" defined as the mutually influencing activity of separate elements. Resonance is an outcome of integration. As we have seen, emotion is inherently an integrative process. By linking mental processes to each other within the single mind and across two or more minds, emotion serves as the fundamental aspect of mental life that serves to "join" or "integrate" minds. The sense of vitality, authenticity, and resonance that arises with narrative coherence and within attuned dyadic relationships can create a deep sense of meaning and connection within oneself and with others. These integrative processes can be proposed to be at the core of emotional well-being and psychological resilience. The ongoing, dynamic process of integration may be fundamental to the evolving mechanisms within the life of an individual, dyad, family or community's continual movement toward mental health.

By examining the convergent scientific findings regarding the social nature of the growing mind, we can come to the view that shared subjective experience is one of the most important aspects of human relationships and of psychological development. This perspective from an interpersonal neurobiology of the developing mind yields a scientific, objective view of the importance of subjectivity in human life.

Attachment research suggests that the mind may continue to develop in response to emotional relationships throughout the lifespan (Lichtenstein-Phelps, Belsky, & Crnic, 1998). These changes in the internal mental models of attachment may be mediated by continuing openness of the brain to change in response to experience. Thus, the possibility remains that ongoing experiences, especially those involving the basic aspects of secure attachments described earlier, may enable some individuals to acquire a more richly developed capacity for neural integration. These basic relationship components include collaborative communication, reflective dialogue, interactive repair, coherent narrativization, and emotional communication. The hope is that interpersonal experiences that involve these basic components will offer respect for the individual's subjective experience within emotionally engaging relationships. Relationships such as those of family, friends, psychotherapy, and the collaborative environment of nurturing communities might facilitate the development of flexible self-regulation and a more integrated way of life for all ages. If we can find a way to facilitate neural integration within the minds of individuals across the lifespan, we may be able to promote a more compassionate world of human connections.

REFERENCES

Aitken, K.J., & Trevarthen, C. (1997). Self-other organization in human psychological development. Development and Psychopathology, 9, 653–678.

Anderson, S.W., Bechara, A., Damasio, H., Tranel, D., & Damasio, A.R. (1999). Impairment of social and moral behavior related to early damage in human prefrontal cortex. Nature Neuroscience 2(11), 1032–1037.

Barbas, H. (1995). Anatomic basis of cognitive-emotional interactions in the primate prefrontal cortex. Neuroscience and Biobehavioral Reviews, 19, 499–510.

Baron-Cohen, S. (1995). Mindblindness: An essay on autism and theory of mind. Cambridge, MA: MIT Press.

Baron-Cohen, S., & Ring, H. (1994). A model of the mind-reading system: Neuropsychological and neurobiological perspectives. In P. Mitchell, & C. Lewis (Eds.), Origins of an understanding of mind (pp. 183–207). Hillsdale, NJ: Lawrence Erlbaum.

Bauer, P.J. (1996). What do infants recall of their lives? Memory for specific events by one-to-two-year-olds. American Psychologist, 51, 29–41.

Beebe B., & Lachman F. (1994): Representation and internalization in infancy: Three principles of salience. Psychoanalytic Psychology, 11, 127–166.

Benes, F.M. (1998). Human brain growth spans decades. American Journal of Psychiatry, 155, 1489.

Bowlby, J. (1969). Attachment and loss. Vol. 1: Attachment. New York: Basic Books.

Bremner, J.D., & Narayan, M. (1998). The effects of stress on memory and the hippocampus throughout the life cycle: Implications for childhood development and aging. Development and Psychopathology, 10, 871–888.

Brewer, J. (1999). The myth of the first three years. New York: Free Press.

Carlson, E.A. (1998). A prospective longitudinal study of disorganized/disoriented attachment. Child Development, 69, 1107–1128.

Cassidy, J., & Shaver, P.R. (Eds). (1999). Handbook of attachment. New York: Guilford Press, 1999.

Chiron, C., Jambaque, I., Nabbot, R., Lounes, R., Syrota, A., & Dulac, O. (1997). The right brain is dominant in human infants. Brain, 120, 1057–1065.

Cicchetti, D., & Tucker D. (1994): Development and self-regulatory structures of the mind. Development and Psychopathology, 6, 533–549.

Cicchetti, D., & Rogosch, F.A. (1997a). The role of self-organization in the promotion of resilience in maltreated children. Development and Psychopathology, 9, 797–816.

Cicchetti, D., & Rogosch, F.A. (1997b). Special issue on self-organization. Development and Psychopathology, 9(4).

Ciompi, L. (1991). Affects as central organising and integrating factors. A new psychosocial/biological model of the psyche. British Journal of Psychiatry, 159, 97–105.

Damasio, A.R. (1998). Emotion in the perspective of an integrated nervous system. Brain Research Reviews, 26, 83–86.

Damasio, A. (1999). The feeling of what happens: Body and emotion in the making of consciousness. New York: Harcourt Brace.

Davidson, R.J. (1992). Prolegomenon to the structure of emotion: Gleanings from neuropsychology. Cognition and Emotion, 6, 245–268.

De Bellis, M.D., Baum, A.S., Birmaher, B., Keshavan, M.S., Eccard, C.H., Boring, A.M. Jenkins, F.J., & Ryan, N.D. (1999a). A.E. Bennett research award. Developmental traumatology. Part I: Biological stress systems. Biological Psychiatry, 45(10), 1259–1270.

De Bellis, M.D., Keshavan, M.S., Clark, D.B., Casey, B.J., Giedd, J.N., Boring, A.M., Frustaci, K., & Ryan, N.D. (1999b). A.E. Bennett research award. Developmental traumatology. Part II: Brain development. Biological Psychiatry, 45(10), 1271–1284.

Dodge, K.A. (1991). Emotion and social information processing. In J. Garber & K.A. Dodge (Eds.), The development of emotion regulation and dysregulation (pp. 159–181). Cambridge: Cambridge University Press.

Dolan, R.J. (1999). On the neurology of morals. Nature Neuroscience 2(11), 927–929.

Edelman G (1992): Bright air, brilliant fire. New York: Basic Books.

Ekman, P. (1992). Facial expressions of emotion: New findings, new questions. Psychological Science, 3, 34–38.

Feldman, R., Greenbaum, C.W., & Yirmiya, N. (1999). Mother–infant affect synchrony as an antecedent of the emergence of self-control. Developmental Psychology, 35, 223–231.

Fogel, A., Lyra, M.C.D.P., & Valsiner, J. (Eds.). (1997). Dynamics and indeterminism in developmental and social processes. Mahwah, NJ: Erlbaum.

Fonagy, P., & Target, M. (1997). Attachment and reflective function: Their role in self-organization. Development and Psychopathology, 9, 679–700.

Fox, N.A. (Ed.). (1994). The development of emotion regulation: Biological and behavioral considerations. Monographs of the Society for Research in Child Development, 240, volume 59.

Garber, J., & Dodge, K.A. (Eds.). (1991). The development of emotion regulation and dysregulation. Cambridge: Cambridge University Press.

Gazzaniga, M.S. (Ed.). (1995). The cognitive neurosciences. Cambridge: MIT Press.

Globus, G., & Arpaia, J.P. (1993): Psychiatry and the new dynamics. Biological Psychiatry, 35, 352–364.

Greenough, W.T., & Black, J.E. (1992). Induction of brain structure by experience: Substrates for cognitive development. In M.R. Gunnar & C.A. Nelson (Eds.), Developmental behavioral neuroscience. The Minnesota symposia on child psychology, vol. 24 (pp. 155–200). Hillsdale, NJ: Erlbaum.

Halgren, E. (1992). Emotional neurophysiology of the amygdala within the context of human cognition. In J. Aggleton (Ed.), The amygdala: Neurobiological aspects of emotion, memory, and mental dysfunction (pp. 191–228). New York: Wiley-Liss.

Harris, J. R. (1998). The nurture assumption. New York: Free Press.

Haxby, J.V., Ungerleider, L.G., Horwitz, B., Maisog, J.M., Rapoport, S.L., Grady, C.L. (1996). Face encoding and recognition in the human brain. Proceedings of the National Academy of Sciences, 93, 922–927.

Hesse, E. (1999). The adult attachment interview: Historical and current perspectives. In J. Cassidy & P. Shaver, (Eds.), Handbook of attachment (pp. 395–433). New York: Guilford Press.

Hofer, M.A. (1994). Hidden regulators in attachment, separation, and loss. In N.A. Fox. (Ed.), The development of emotion regulation: Biological and behavioral considerations. Monographs of the Society for Research in Child Development, 240, vol. 59 (pp. 192–207).

Izard, C.E., & Kobak, R.R. (1991). Emotions system functioning and emotion regulation. In: J. Garber & K.A. Dodge (Eds.), The Development of Emotion Regulation and Dysregulation (pp. 303–322). Cambridge: Cambridge University Press.

Johnson-Laird, P.N. (1983). Mental models: Towards a cognitive science of language, inference, and consciousness. Cambridge, MA: Harvard University Press.

Kandel, E.R., & Schwartz, H. (Eds.). (1992). Principles of neural science, 2nd ed. New York: Elsevier.

Kandel, E.R. (1998). A new intellectual framework for psychiatry. American Journal of Psychiatry, 155, 457–469.

LeDoux, J.E. (1996). The emotional brain: The mysterious underpinning of emotional life. New York: Simon and Schuster.

Lewis, M.D. (1995). Cognition-emotion feedback and the self-organization of developmental paths. Human Development, 38, 71–102.

Lewis, M.D. (1997). Personality self-organization: Cascading constraints on cognition-emotion interaction. In Fogel, A., Lyra, M.C.D.P., & Valsiner, J. (Eds.), Dynamics and indeterminism in developmental and social processes (pp. 193–216). Mahwah, NJ: Erlbaum.

Lichtenstein Phelps, J., Belsky, J., & Crnic, K. (1998). Earned security, daily stress, and parenting: A comparison of five alternative models. Development and Psychopathology, 10(1), 21–38.

Liotti, G. (1992). Disorganized/disoriented attachment in etiology of dissociative disorders. Dissociation, 5, 196–204.

Liu, D., Dioria, J., Tannenbaum, B., Caldji, C., Francis, D., Freedman, A., Sharma, S., Pearson, D., Plotsky, P.M., & Meaney, M.J. (1997). Maternal care, hippocampal glucocorticoid receptors, and hypothalamic–pituitary–adrenal responses to stress. Science, 277, 1659–1662.

Lyons-Ruth, K., Alpern, L., & Repacholi, B. (1993). Disorganized infant attachment classification and maternal psychosocial problems as predictors of hostile-aggressive behavior in the preschool classroom. Child Development, 64, 572–585.

Lyons-Ruth, K., & Jacobwitz, D. (1999). Attachment disorganization: Unresolved loss, relational violence, and lapses in behavioral and attentional strategies. In J. Cassidy & P.R. Shaver (Eds.), Handbook of attachment: Theory, research, and clinical applications (pp. 520–554). New York: Guilford.

Main, M. (1995). Attachment: Overview, with implications for clinical work. In S. Goldberg, R. Muir, & J. Kerr (Eds.), Attachment theory: Social, developmental and clinical perspectives (pp. 407–474). Hillsdale, NJ: Analytic Press.

Main, M., & Hesse, E. (1990). Parents' unresolved traumatic experiences are related to infant disorganized status: Is frightened and/or frightening parental behavior the linking mechanism? In M. Greenberg, D. Cicchetti, & M. Cummings (Eds.), Attachment in the preschool years (pp. 161–182). Chicago: The University of Chicago Press.

Main, M., & Morgan, H. (1996). Disorganization and disorientation in infant strange situation behavior: Phenotypic resemblance to dissociative states. In L.K. Michelson & W.J. Ray (Eds.), Handbook of dissociation: Theoretical, empirical, and clinical perspectives. New York: Plenum Press.

McClelland, J.L. (1998). Complementary learning systems in the brain: A connectionist approach to explicit and implicit cognition and memory. Annals of the New York Academy of Sciences, 843, 153–178.

Milner, B., Squire L.R., & Kandel, E.R. (1998). Cognitive neuroscience and the study of memory. Neuron, 20, 445–468.

Mesulam, M.M. (1998). Review article: From sensation to cognition. Brain, 121, 1013–1052.

Nelson, C.A., & Bloom, F.E. (1997). Child development and neuroscience. Child Development, 68(5), 970–987.

Nelson, C.A., & Carver, L.J. (1998). The effects of stress and trauma on brain and memory: A view from developmental cognitive neuroscience. Development and Psychopathology, 10, 793–810.

Nobre, A.C., Coull, J.T., Frith, C.D., & Mesulam, M.M. (1999). Orbitofrontal cortex is activated during breaches of expectation in tasks of visual attention. Nature Neuroscience, 2, 11–12.

Ogawa, J.R., Sroufe, L.A., Weinfeld, N.S., Carlson, E.A., & Egeland, B. (1997). Development and the fragmented self: Longitudinal study of dissociative symptomatology in a nonclinical sample. Development and Psychopathology, 9, 855–880.

Panskepp, J. (1982). Toward a general psychobiological theory of emotions. Behavioral and Brain Sciences, 5, 407–467.

Robertson, R., & Combs, A. (Eds.) (1995). Chaos theory in psychology and the life sciences. Mahwah, NJ: Erlbaum.

Rolls, E.T. (1995). A theory of emotion and consciousness, and its application to understanding the neural basis of emotion. In M.S. Gazzaniga, (Ed.), The cognitive neurosciences (pp. 1091–1106). Cambridge: MIT Press.

Rosenblum, L.A., Coplan, J.D., Friedman, S., Basoff, T., Gorman, J.M., & Andrews, M.W. (1994). Adverse early experiences affect noradrenergic and serotonergic functioning in adult primates. Biological Psychiatry, 35, 221–227.

Ross, E.D., Homan, R.W., & Buck, R. (1994). Differential hemispheric lateralization of primary and social emotions: Implications for developing a comprehensive neurology of emotions, repression, and the subconscious. Neuropsychiatry, Neuropsychology, and Behavioral Neurology, 7, 1–19.

Schacter, D.L, & Buckner, R.L. (1998). Priming and the brain. Neuron, 20, 185–195.

Schore A.N. (1994). Affect regulation and the origin of the self: The neurobiology of emotional development. Hillsdale, NJ: Erlbaum.

Schore, A.N. (1996). The experience-dependent maturation of a regulatory system in the orbital prefrontal cortex and the origin of developmental psychopathology. Development and Psychopathology, 8, 59–87.

Schore, A.N. (1997). Early organization of the nonlinear right brain and development of a predisposition to psychiatric disorders. Development and psychopathology, 9, 595–631.

Siegel, D.J. (1999). The developing mind: Toward a neurobiology of interpersonal experience. New York: Guilford.

Siegel, D.J. (1996). Cognition, memory, and dissociation. Child and Adolescent Clinics of North America, 5, 509–536.

Siegel, D.J. (1995). Memory, trauma, and psychotherapy: A cognitive science view. Journal of Psychotherapy Practice and Research, 4, 93–122.

Springer, S.P., & Deutsch, G. (1993). Left brain, right brain. New York: W.H. Freeman.

Sroufe, L.A. (1996) Emotional development: The organization of emotional life in the early years. New York: Cambridge University Press.

Stern, D.N. (1985). The interpersonal world of the infant. New York: Basic Books.

Stone, V.E., Baron-Cohen, S., & Knight, R.T. (1998). Frontal lobe contributions to theory of mind. Journal of Cognitive Neuroscience, 10(5), 640–656.

Thatcher, R.W. (1997). Human frontal lobe development: A theory of cyclical cortical reorganization. In N.A. Karsnegor, G. Reid-Lyon, & P.S. Goldman-Rakic (Eds.), Development of the prefrontal cortex: Evolution, neurobiology, and behavior (pp. 85–113). Baltimore: Brookes Publishing.

Thelen, E. (1989). Self-organization in developmental processes: Can systems approaches work? In M. Gunnar & E. Thelen (Eds.), Systems and development. The Minnesota symposium in child psychology, vol. 22 (pp. 77–117). Hillsdale, NJ: Erlbaum.

Toth, S.L., Cicchetti, D., Macfie, J., & Emde R. (1997). Representations of self and other in the narratives of neglected, physically abused and sexually abused preschoolers. Development and Psychopathology, 9, 781–796.

Trevarthen, C. (1990). Integrative functions of the cerebral commissures. In F. Boller & J. Grafman (Eds.), Handbook of Neurospsychology, 4, 49–83.

Trevarthen, C. (1996). Lateral asymmetries in infancy: Implications for the development of the hemispheres. Neuroscience and Biobehavioral Reviews, 20, 571–586.

Tucker, D.M. (1992). Developing emotions and cortical networks. In M.R. Gunnar & C.A. Nelson, (Eds.), Minnesota symposium on child psychology: vol. 24, Developmental behavioral neuroscience (pp. 75–128). Hillsdale, NJ: Erlbaum.

Tucker, D.M., Luu, P. & Pribram, K.H. (1995). Social and emotional self-regulation. Annals of the New York Academy of Sciences, 213–239.

Tulving, E., Kapur, S., Craik, F.I.M., Moscovitich, M., & Houle, S. (1994). Hemispheric encoding/retrieval asymmetry in episodic memory: Positron emission tomography findings. Proceedings of the National Academy of Sciences USA, 91, 2016–2020.

van Ooyen, A., & van Pelt, J. (1994). Activity-dependent neurite outgrowth and neural network development. Progress in Brain Research, 102, 245–259.

Watt, D.F. (1998). Affect and the limbic system: Some hard problems. Journal of Neuropscyhiatry, 10, 113–116.

Webster's Collegiate Dictionary. (1996). New York: Random House.

Wheeler, M.A., Stuss, D.T., & Tulving, E. (1997). Toward a theory of episodic memory: The frontal lobes and autonoetic consciousness. Psychological Bulletin, 121(3), 331–354.

Wilson, E.O. (1998). Consilience: The unity of knowledge. New York: Vintage.

Wolf, D.P. (1990). Being of several minds: Voices and versions of the self in early childhood. In D. Cicchetti & M. Beeghly (Eds.), The self in transition: Infancy to childhood (pp. 183–212). Chicago: University of Chicago Press.