The Developing Mind and the Resolution of Trauma: Some Ideas about Information Processing and an Interpersonal Neurobiology of Psychotherapy

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Preface

This chapter provides an overview of an interdisciplinary approach to understanding the nature of the developing mind and how the unresolved effects of trauma may come to be resolved within psychotherapy. A brief historical background may be helpful from the beginning. Francine Shapiro and I met for the first time at a trauma conference in which we were both members of the panel of lecturers.[1] It was exhilarating to see the parallels in our conceptual thinking despite the marked differences in the origins of our models. Her work in developing EMDR and the growing clinical and research interest in it as a method of treatment provided the background in which she developed the view of an "accelerated information processing" foundation for EMDR's mechanism of action. My own work comes from an interdisciplinary approach that combines a number of independent fields, including attachment theory and research, cognitive neuroscience, complexity theory, developmental psychology and psychopathology, genetics, psycholinguistics, and the study of trauma. By weaving the findings from these varied disciplines together with clinical work as a child psychiatrist, I have been able to develop a conceptual framework that has recently been published as a book entitled, The Developing Mind: Toward a neurobiology of interpersonal experience. This chapter will offer a brief overview of this work and highlight ways in which this "interpersonal neurobiology" approach may help in understanding some possible mechanisms underlying trauma and its resolution.

Due to space limitations, this chapter can only function as a brief condensation and initial introduction to this interdisciplinary perspective. A more extensive presentation and thorough discussion of the research background as well as details about the specific scientific reasoning and references that form the foundation for this framework can be found in The Developing Mind text and related publications.[2] With this framework as a foundation, the chapter will highlight possible parallels to some of the processes that may be involved in various forms of effective psychotherapy,

specifically focusing on EMDR as an example of a clinical method that may promote accelerated information processing and the resolution of trauma.

An Interpersonal Neurobiology of the Developing Mind and Unresolved Trauma

The field of mental health is in a tremendously exciting period. Recent findings from cognitive neuroscience have revealed some new insights into how mental processes emerge from the activity of the brain. Independent advances in the science of development, especially longitudinal studies in the field of attachment, shed new light on how early experiences influence such fundamental processes as memory, emotion, and the regulation of behavior. The often isolated fields of neurobiology and attachment have a fascinating set of convergent findings relevant to the understanding of trauma. Examination of these and other areas of research can offer us new ways of understanding how the developing mind is shaped by the interaction of interpersonal experience and neurobiological processes in the creation of the human mind.

The mind develops throughout life as we interact with others in our environment. The genetically influenced timing of the emergence of specific brain circuits during the early years of life makes this a time of exquisite importance for the influence of interpersonal relationships – with parents and other caregivers – on how the structure and function of the brain will develop and give rise to the organization of the mind. Overwhelmingly stressful experiences may have their largest impact on the growth of the mind at the times when specific areas of the brain are in rapid periods of development and reorganization. For this reason, the early years of life may be a time of both enhanced opportunity as well as of vulnerability. Trauma during the early years may have lasting effects on deep brain structures responsible for such processes as the response to stress and the encoding of memory. As we'll see, specific "states of mind" can also be deeply engrained as a form of memory of trauma; these too can be a lasting effect of early traumatic experience.

How does experience affect the brain? How can human relationships, supportive or traumatizing, influence the activity and development of the brain? What are the mechanisms by which interpersonal experience can actually shape neuronal activity and growth? These questions have led me to become immersed in a pursuit of a "neurobiology of interpersonal experience": a way of understanding the neurobiological processes by which the mind emerges from the activity of the brain in interaction with other brains – with other minds. Some of the more devastating effects of trauma occur within relationship-based experiences, such as domestic violence or child abuse. Grounding ourselves in a neuroscience of relationships can allow us in the field of mental health to approach our work with a deeper understanding of the central importance of interpersonal experience in creating the subjective life of the mind.

MIND, BRAIN AND EXPERIENCE

What is the mind? How do the processes of the mind emerge from the neuronal activity of the brain? Though it cannot be seen with or without a microscope, the mind

does have an organization to its processes that can be described and studied. Mental processes such as memory, emotion, attention, behavioral regulation and social cognition can be understood by examining the nature of brain activity. Recent technological advances have permitted truly new insights into the nature of the mind. For example, our modern view of the brain and its response to experience has shed some new light on how experience directly affects gene function, neuronal connections and the organization of the mind.

The brain itself is composed of a massively complex network of interconnected neurons which number about one hundred billion. The activity of neurons occurs in a network of activation – a certain portion of a spider-web like neural network active across time. It is the specific pattern of this brain activity across time that determines the nature of the mental processes created at a given moment: the timing and the location of neural activation within the brain determine the "information" contained within the neural net patterns or neural "maps." Activity in sensory regions may mediate perception and the specific nature of this firing may signify the different aspects of perceptual information: a visual stimulus, auditory input or tactile sensation, for example. Information carried within perceptual regions often becomes integrated into a larger "cross-modal" perceptual system. Such an integrating process is an example of how the brain functions as a hierarchical set of layers of relatively distinct component elements or processing modalities whose neuronal activity may become clustered together into a functional whole.

The brain as a system is composed of hierarchical layers of component parts that can be examined at a number of levels of analysis: single neurons, neuronal groups, circuits, systems, regions, and hemispheres. At birth the brain is the most undifferentiated of any "organ" in the body. As development unfolds, neural pathways are created as synapses are formed which allow for the creation of these component parts to become differentiated and to carry out such features as attention, perception, memory and emotional regulation. A huge number of genes encode for the timing and general details of how circuits are to develop early in life. However, the creation, maintenance and elaboration of neural connections may often also require that they be activated in a process sometimes called experience- or activity-dependent development. Experience activates specific neuronal connections and allows for the creation of new synapses and the strengthening of existing ones. In some cases, lack of use leads to impaired synaptic growth and to a dying away process – called pruning – in which connections are lost and neurons themselves may die. Such a pruning process appears to be a major event during the adolescent years in which the huge increase in synaptic density created during the early years is then pruned to the lower densities of the adult years. How genetically encoded information interacts with environmental and interactive elements to determine the nature of this important adolescent pruning period is open to future investigations.

The differentiation of the brain during the early years of life is dependent upon both genetic information and proper experiential stimulation. It is for this reason that the early years of life, the time when the basic circuits of the brain are becoming established that mediate such processes as emotional and behavioral regulation, interpersonal relatedness, language and memory, are the most crucial for the individual to receive the kinds of experience that enable proper development to occur. Attachment studies suggest that these "experiences" are about the interactions between the child and the environment, especially within the social world in which the child lives, rather than merely the "sensory bombardment" that some parents have come to feel pressured to

offer to their children in the form of visual or auditory stimulation in hopes of "building better brains." As we'll see, the "experiential food" for the mind is in the form of collaborative communication rather than sensory overload.

But how does experience actually influence neurons and the genes that encode, in part, their growth and development? Numerous studies demonstrate that genes have two major functions: 1) genes store information in their "template" function; and 2) genes are expressed in their "transcription" function in which they lead to the production of specific proteins which alter cell structure and function. The activation of neurons during experience leads to the creation of new synaptic connections by the activation of genes that cause the production of the proteins necessary for neuronal growth and synapse formation. Genes do not exist in a vacuum but may require experience for their expression. Genes can be activated by experience, revealing the biological reality that experience directly shapes brain structure via the activation of genes. In the end, experience affects the mind by altering the synaptic connections within the brain. Brain development can be seen as a result of several processes, including the extensive growth of synapses that are strengthened, maintained or allowed to die away; the creation of new synapses in response to experience and its activation of neurons; the alteration of neurotransmitter release and receptor density and sensitivity; the myelination of neural sheaths that allows for an increased conduction speed of the action potential down the length of the axon, thus functionally increasing the connectivity of neurons. Recent findings in neurobiology suggest that the brain may continue to develop across the lifespan. Such growth may take place in the ongoing modification of synapses as well as the possible growth of new neurons. In some cases, neurons that integrate widely distributed areas in the brain may continue to grow beyond the early years of life (Benes, 1998). As we explore the nature of trauma, we need to focus on how traumatic experience may alter synaptic connections in such a manner that impairs subsequent functioning in unresolved states. As we'll see below, one proposal is that trauma directly impairs the capacity to integrate a range of cognitive processes into a coherent whole. Recent studies of brain anatomy in abused children have demonstrated an associated reduction in overall brain size as well as the specific finding of impairments in the development of the corpus callosum, the bands of neural tissue allowing for the transfer of information between the two halves of the brain (De Bellis, et al, 1999b and 1999c).

THE MIND: PATTERNS IN THE FLOW OF ENERGY AND INFORMATION

A variety of disciplines explore the nature of the mind in its ability to process information and to regulate the function of the individual in adapting to the environment. These various conceptualizations of mind often share the notion that the mind is more than a physical entity – such as brain activity alone – and yet emerges from and also regulates the "self" and the physiological processes from which it emerges. The mind is thus often seen as a "process" fundamental to each person. A dictionary definition of the psyche includes the terms soul, intellect, spirit and mind. In attempting to put these various perspectives into a broader framework, it has been useful to have a working definition that views the mind as emerging from the patterns in the flow of energy and information within the individual and between individuals. In this way, the mind is

created by both neurobiological processes within the individual and interpersonal interactions between individuals.

The activity of the brain serves to process information within its energized neural patterns. Information is processed in the brain by means of patterns of neural activity which serve to "represent" aspects of the internal or external world. This mental "symbol", "code", or "image" is conceptualized as being embedded within patterns of neural net firing, sometimes called a neural net "profile" or neural "map." For example, when we recall a visual image, such as the house we grew up in, the firing of a pattern of neural circuits within our visual system is similar but not identical to the pattern or map that fired when we were actually there years ago. Memory, as with other mental processes including ongoing perception, is an actively constructive process that draws on a range of neural systems and is shaped by a wide variety of external and internal factors. Within the brain, the pattern of activation (energy) of distributed neurons acts as a symbol (information) of some experienced event that is constructed by the mind itself.

Information is represented in the mind by way of the flow of neural activity across various spatially distributed circuits. The way in which these representations become functionally linked and cause further effects in the mind – such as contrasting, clustering into categories, extracting general properties – is the essence of information processing. The resultant neural activity becomes a mental symbol itself and creates a cascade of representational processes that are at the heart of the flow of cognition.

Colwyn Travarthen (1996) and Tucker, Luu and Pribram (1995) have described the ways in which the right and left hemisphere are dominant for the mediation of distinct modes of representational processing. From before birth, the brain reveals an asymmetry in its structure and development. For the infant, the right hemisphere is dominant in its growth during the first three years of life. It is thus likely to be more vulnerable to the effects of trauma during this crucial period. Recent discoveries over the last several decades have resulted in a number of fascinating notions about the divided brain and mental processes. For the purposes of this chapter, I will highlight those findings that are particularly relevant to understanding trauma and its resolution. Most of these findings are from the majority of individuals who have the characteristic "dominance" (language function) of the left hemisphere, as is typically found in right-handed individuals. In these people, the left hemisphere is dominant for the semantic aspects of language, syllogistic reasoning (drawing cause-effect relationships), and linear analysis. The right hemisphere is usually dominant for nonverbal aspects of language (tone of voice, gestures), facial expression of affect, the perception of emotion, the regulation of the autonomic nervous system, the registration of the state of the body and for social cognition including the process called "theory of mind."

Some views suggest that the right hemisphere is able to experience more intense emotionally arousing states of mind. Furthermore, the retrieval of autobiographical memory appears to be mediated by the right hemisphere. Also, both the registration and the regulation of the body's state appear to be predominantly mediated by the right hemisphere. Recent studies of flashback conditions suggest an intense activation of the right hemisphere visual cortex and an inhibition of left hemisphere speech areas (Rauch et al, 1996). As we'll discuss below, impairment in representational integration in general, including the bilateral integration of information processing between right and left hemispheres in particular, can be proposed to be a core deficit in unresolved trauma. Therapeutic interventions that enhance neural integration and collaborative inter-hemisphere function may be especially helpful in

moving unresolved traumatic states toward resolution. The strategic activation of specific information processing modalities may be a possible mechanism of action in the creation of coherent narratives, as can be seen as an outcome in various approaches to the treatment of individuals with PTSD, including Cognitive Behavior Therapy (CBT), psychodynamic psychotherapy, and EMDR. As discussed further on in this chapter, specific elements of the EMDR method may be selectively activating representational processes that are dominant in each hemisphere and their simultaneous activation may move the brain to link these otherwise isolated processes into a functional whole.

An overview of the relationship between attachment and mental health reveals that the most disturbed form of attachment, called "disorganized/disoriented" attachment, is associated with the most disturbed developmental outcome (Lyons-Ruth and Jacobwitz, 1999). These children are more likely to have cognitive, emotional and social impairments later in life. The experience of these children with their caregivers has been proposed by Main and Hesse (1990) to involve frightened, frightening or disoriented behavior on the part of the parent. Two important findings are: 1) these children are prone to develop dissociative symptoms (Carlson, 1998); and 2) the parent's autobiographical narrative of his or her own childhood reveals discourse features consistent with "unresolved trauma or grief" (Hesse, 1999). In this manner, the adult's attachment classification (based on the adult attachment interview or AAI) is described as Unresolved/disorganized (Hesse, 1999). It is here that the field of attachment raises a crucial clinical "red flag" of warning regarding the intergenerational transmission of trauma. These findings also raise the important question of what "unresolved" trauma means for the functioning of the mind and the brain. These issues and this question are a primary focus of The Developing Mind.

MEMORY

Recent discoveries in the development and neurobiology of memory have yielded some exciting and relevant insights into the nature of how our minds respond to experience and influence later functioning (Milner, Squire and Kandel, 1998). Two major forms of memory have been described: implicit and explicit. Implicit memory includes a range of processes such as emotional, behavioral, perceptual and possibly somatosensory memory. These forms are present at birth and involve circuitry that does not require focal attention for encoding nor does it include a sense of "I am recalling something" when retrieval occurs. This sensation is believed to be a part of "explicit memory", described below, which requires the maturation of areas of the brain, including the hippocampus, that does not occur until after the first year of life. For example, an infant bitten by a dog may have the emotional memory of fear when seeing a dog in the future, but may have no sense that she is "recalling" anything when having this sensation. Implicit memory is available but explicit memory is not at this age due to the genetically programmed timing of maturation of different circuits in the brain. Implicit memory is NOT the same as nonconscious memory in that the effects of the recall are indeed within conscious awareness but are only experienced in the "here and now" and not with the subjective sense that something is being recalled. These implicit forms of memory are thought to be carried out in areas of the brain that subsume their functions such as the amygdala and other areas of the limbic system (emotional memory), basal ganglia and motor cortex (behavioral memory), and the sensory cortex (perceptual

memory). These regions are relatively well developed at birth and capable of responding to experience by alterations in the synaptic connections within their circuitry, the essence of "memory encoding."

Another important aspect of implicit memory is the ability of the mind to form schema or mental models of experience. These generalizations can be across experiences and across sensory modalities and reflect the brain's inherent capacity to function as an "anticipation machine" – deriving from ongoing experience an anticipatory model of what may occur in the future. Making mental models conscious may be a part of a "self-concept" and may be revealed during EMDR during the "negative" self-belief or self-statement phase of the method. Mental models can also be seen within the "in-between-the-lines" themes of the narratives that structure both our life stories and the manner in which we live our daily lives.

Explicit memory requires focal attention for its encoding and appears to activate a region of the brain called the medial temporal lobe, including the hippocampus. The postnatal maturation of parts of the hippocampus may explain the delayed onset of explicit memory until after the first year of life. When explicit memory is retrieved, it has the subjective sense of "something being recalled." Explicit memory includes two major forms: Semantic (factual) and episodic (autobiographical). This latter form of memory has the unique features of a sense of self and time. Recent brain imaging studies suggest that episodic memory is mediated by a number of regions including an area of the brain called the orbitofrontal cortex. The maturation (synapse formation and myelination) of this and related parts of the prefrontal cortex during the preschool years may be the neurobiological basis for the emergence and continued development of autobiographical memory and self-awareness during this period of childhood and beyond. Ernst Tulving and colleagues (Wheeler, Stuss and Tulving, 1997) use the phrase, "autonoetic consciousness" to refer to the ability of the mind to know the self and to carry out "mental time travel" –seeing the self in the past, present and possible future. The development of the orbitofrontal regions during the first years of life may help us to understand the onset of this autonoetic capacity during the toddler and preschool periods. The possible ongoing development of this region may also explain the ways in which experience may continue to shape the way we come to understand ourselves and the world in which we live throughout the lifespan.

There is a tremendously exciting convergence of findings regarding the orbitofrontal region which suggest a number of highly relevant processes subsumed by this coordinating area of the brain. Located in the prefrontal cortex just behind the eyes, and sitting at the junction of the "limbic system" (including the anterior cingulate cortex, hippocampus, and amygdala) and the associational regions of the neocortex, this convergence area receives input from and sends neural pathways to a wide array of perceptual, regulatory, and abstract representational regions of the brain. In this manner, the orbitofrontal cortex serves to integrate information from widely distributed systems and also to regulate the activity of processes ranging from memory representations to the physiological status of the body, such as heart-rate and respiration. The orbitofrontal cortex : 1) Has been suggested to be dependent upon attachment experience for its growth and its mediation of emotionally "attuned communication"(Schore 1994, 1996); 2) Plays a primary role in mediating autonoetic consciousness (Wheeler, Stuss and Tulving, 1997); 3) Monitors the state of the body and regulates the autonomic nervous system as well as being a primary circuit of stimulus appraisal which evaluates "meaning" of events (Damasio, 1994); and 4) It appears to be an important region subsuming social cognition and "theory of mind"

processing (Baron-Cohen, 1995). Interestingly, it appears that it is the orbitofrontal cortex on the right side of the brain that is dominant for most of these processes. Each of these basic aspects of the developing mind are mediated by the same self-regulating, experience-dependent circuits that have their initial differentiation during the early years of life.

The following proposal regarding bilateral neural integration, memory consolidation, and the resolution of trauma is based on a number of independent, empirically derived views regarding memory, brain function and the clinical findings in posttraumatic stress disorder. This hypothesis has been offered as a possible integration of a range of convergent findings and awaits future empirical studies to support its suggestions. The background findings relevant to this hypothesis include: A) Tulving and colleagues (1994) have suggested a "hemisphere encoding and retrieval asymmetry" hypothesis that postulates that for autobiographical memory there is an encoding role for the left orbitofrontal region and a retrieval role for the right. B) Explicit memory is thought to proceed through a series of stages of encoding that include: 1) initial registration in sensory memory (lasting less than half a second); 2) encoding into working memory (lasting half a minute); 3) encoding into long-term memory (lasting days to months to years); and 4) the consolidation of elements of long-term memory into permanent memory (a process that may take days to months to occur and then makes these representations a part of an integrated network within the associational cortex and independent of the hippocampus for later retrieval) (McClelland, 1998). C) REM sleep is essential for the consolidation of memory in which emotional elements of past events become woven together with thematic components of memory to achieve a re-integration or "consolidation" of memory representations. I have proposed that the autobiographical narrative process may be a fundamental part of cortical consolidation. In this manner, dreams may be seen as an emotionally driven narrative process that incorporates elements of distant and more recent past events as well as ongoing perceptions and random activations in the re-organization (not new encoding) of existing memory traces. This reveals how memory retrieval can be a form of memory modification (Bjork, 1989). Unresolved trauma can be seen as an impairment in this consolidation process of memory. Such an impairment may be revealed within the REM sleep disturbances and nightmares so prevalent in PTSD, as well as in the incoherent narratives and intrusive implicit elements of memory that torment the individual's internal subjective world and interpersonal relationships.

Here is the proposal: Unresolved trauma involves the impairment of integration of representational processes within the brain. This impairment can lead to an array of findings within PTSD and also may make the individual vulnerable to entering inflexible, reactive states of heightened emotion that lack self-reflection. At the core of "unresolved trauma" is an impairment in a core process of neural integration. One expression of this impairment can be seen in the blockage of the consolidation of memory (and the resolution of the trauma) that occurs normally via a proposed bilaterally activating process in which the right hemisphere becomes activated and creates an autonoetic retrieval state. The transfer of information from the right to the left enables the left hemisphere to utilize these representations as part of its autonoetic encoding state. In essence, the reactivated autobiographical representations (right) become the basis for newly reorganized autobiographical encoding (left). Dreams function within REM to enable this consolidation process to occur. Narratives reflect an internal, nonverbal process of neural integration which may become ultimately expressed in words. Coherent narratives – non-verbal or language-based – emerge from such a bilaterally

integrating process. The process of bilateral integration can thus be proposed to be one of the core elements in resolution.

The narrative process, so fundamental to many forms of psychotherapy, may also facilitate (as well as reveal) this integration across the hemispheres. It is important to note, however, that the core issue is one of representational integration. These representations or mental images may be manifested in an array of modalities, from various forms of perception (sight, hearing) to words. It is thus quite likely that therapeutic progress (increased integration) may give rise to increased coherence of autobiographical narratives. This suggests that the interpersonal sharing of the internal experience in words alone may not be the core curative feature within therapy. Such sharing may require a range of representational modalities, divided at the most basic level between the non-verbal and the verbal. The sense of safety and emotional "holding environment" of a secure attachment within a therapeutic relationship, discussed later in the chapter, may be essential for these integrative processes to (finally) occur within the traumatized person's mind. Future research will be needed to examine if this proposed neural integration and resolution process is associated with alterations in neural function and possibly changes in specific integrative neural circuits, such as those in the corpus callosum, cerebellum, prefrontal, and anterior cingulate regions.

EMOTION

Researchers have addressed the topic of emotion by looking at the level of psychological function, attachment theory, and more recently at neurobiological substrates of emotional development. This proposed "interpersonal neurobiological" approach examines the fundamental role of emotion by drawing on various levels of analysis – from neuronal processes to interpersonal relationships – in viewing the individual mind as a system and the relationship between individuals as a way in which two minds come to function as a dyadic system. This perspective allows us to move back and forth between neuronal activity and mental function and between individual and dyadic processes.

Though there are a wide range of details about how researchers attempt to define emotion, many authors point to a number of common features (Sroufe, 1996, Garber and Dodge, 1991). Emotion is often considered as a way in which the mind appraises the meaning of a stimulus, is a response to engagement with the world, and prepares the self for action. Emotion is also seen as having a number of levels of manifestation, including subjective, cognitive, physiological and behavioral components.

A fascinating recursive finding has been noted by a number of authors in terms of the regulation of emotion: Emotion is both regulated and is regulatory. In other words, the process of emotion serves to regulate other mental processes and is itself regulated by mental processes. This view supports the more recently held perspective that there are no discernible boundaries between our "thoughts" and "feelings." Emotion influences and is influenced by a wide range of mental processes. Another way of stating this is that emotion, thought, perception, memory and action are inextricably interwoven. This linkage is exemplified by the idea that perception is the brain's preparation for action: There is no perception without the potential for action upon incoming stimuli. Thus, regions mediating "perception" are directly influenced by those which respond, internally and behaviorally, to perceptual representations. Likewise,

modern views of the brain circuitry subsuming emotional processes support the view that all layers of the brain are influenced by the emotion generating regions. In fact, recent views of the neurobiology of emotion suggest that the limbic region – which includes the orbitofrontal cortex, anterior cingulate, hippocampus, and amygdala – has no clearly definable boundaries. This suggests that the integration of a wide array of functionally segregated processes, such as perception, abstract thought and motor action, may be a fundamental role of the brain. Such an integrative process may be at the core of what emotion does and indeed what emotion is. As we've proposed, trauma may exert its effects by directly impairing the core integrative capacity of the mind. In its essence, this means that trauma may cause neuronal patterns to become engrained which restrict the ability of the brain to functionally cluster independent modes of information processing. As we'll see, such a restriction may occur within a single brain (such as functional isolation of one hemisphere from the other) or between brains (such as in rigidly constrained interpersonal communication as is seen with intra-familial child abuse). Resolution of trauma, from this perspective, can be seen to require a movement toward freeing the innate tendency of the mind to integrate its functions.

The brain as a system can be seen to function as a set of differentiated neuronal groups and circuits that can be clustered into a functionally integrated set of activations. Edelman (1992) has described the importance to such a cluster of interacting parts of having a "value" system that can reinforce or "select" certain stimuli and neuronal responses as valued preferentially over others. A range of neuromodulatory systems, including the limbic regions, can be proposed to meet the criteria for a value system of the brain. Such a value system must have extensive innervation to far reaching areas of the brain, have the effect of enhancing the excitability and activation of neurons, and influence their plasticity (the capacity to strengthen and form new neuronal connections). In this manner, the limbic regions may be conceptualized as a primary source of "value" for the brain. The central location of limbic structures, especially the orbitofrontal cortex and anterior cingulate, may allow for these areas to play a crucial role in the neural integration of neocortical, limbic, and deeper structures (responsible for states of alertness and bodily function).

What we can now say about the neuronal functions directly related to emotion is that there is believed to be an interdependence of several important domains of mental processes: stimulus appraisal (the evaluation of meaning), neural circuit activation, social communication, bodily state, and autonomic regulation each appear to be mediated by a closely linked system of neural circuits. Interestingly, these elements of the "self" appear to be fundamentally linked to the neural substrates of various forms of consciousness (Damasio, 1999). Emotion, bodily state and a "core consciousness" of the self emerge from within the same circuitry within the brain. The significance of this finding is that it explains how communication within attachment relationships is the primary experience that regulates and organizes the development of those circuits in the brain that mediate self-regulation and social relatedness. A sense of self emerges directly from self-other interactions (Stern, 1985). Early in life, when the infant's brain is developing the circuitry responsible for these domains, attachment relationships help the experience-dependent growth of crucial neuromodulatory regions responsible for emotional regulation (Schore, 1994). Trauma during this early period, especially in those that may be genetically vulnerable to the effects of stress on the unfolding of brain structures, may have devastating effects on the development of these basic mental processes that create the self. As discussed earlier, the overwhelming stress of early abuse appears to be associated with significant alterations in brain development and function (De Bellis, et al, 1999a and 1999b).

Sharing emotional states is a direct route by which one mind becomes connected to another. The brain's evaluation of the meaning of events – the information – is linked to the activation of neural circuits – the energy. Our internal experience of emotion becomes in essence the "music of the mind" – the rhythmic flow of energy and information through our neural circuitry. Our interpersonal sharing of emotion, seen within attuned communications of secure attachments, is the way in which the flow of energy and information occurs – often nonverbally – between two individuals' minds. Such a sharing of nonverbal signals may be one way in which the right hemisphere of one person "joins" with the right hemisphere of the other. The right hemisphere may have a far greater role than the left in both the regulation of bodily and emotional state as well as in mediating social and emotional communication. This attunement of right-to-right hemisphere may be crucial in establishing the secure attachment environment which may be essential for effective therapy to occur. This therapeutic process thus can be seen as enabling the therapist to serve in a similar role as an attachment figure: as a part of an interactive relationship that enables the "co-regulation" of internal states to eventually lead to more autonomous "self-regulation" of emotional states within the individual's own mental processes.

Within neural circuits, the systems that mediate the perception of social communication – especially the nonverbal messages within facial expressions, gestures and tone of voice – are closely linked to those that appraise the meaning of stimuli and regulate the activation of the autonomic nervous system. These circuits appear to be predominantly in the right hemisphere. Thus, information and energy flow are directly regulated by the regions that carry out and perceive interpersonal communication! It is with this new awareness that we can see the mechanisms underlying the long held belief in how powerful human relationships are in organizing our continually emerging minds. Within psychotherapy, the nonverbal behavior of the therapist is crucial for establishing a sense of safety and security within the fragile and vulnerable conditions of the therapeutic work. The distinct but equally important logical and linguistic output of the left hemispheres of patient and therapist find a different manner in which the two come to "join" in the therapeutic process as discussed later in the chapter.

STATES OF MIND and SELF-REGULATION

The capacity of the mind to self-organize can be explored by examining the nonlinear dynamics of complex systems, or complexity theory. Modern applications of this systems view to the human mind have yielded some powerful ideas for understanding development. In essence, these applications suggest a number of relevant concepts: self-organization, the movement toward increasingly complex states of activation, and the regulation of the state of activation of a system by both internal and external factors called "constraints." In early development, the parent's mind acts to both alter the present state of the child's mind and to help form the neural circuits which will enable the child's brain to regulate itself in increasingly sophisticated ways as the child matures. Interaction between parent and child thus serves to help self-organization both in the interactive moment and in creating self-organizational neural capacities for the future. Parental behavior that produces disorganization within the child's mind thus may create not only an impairment in functioning in the moment, but, if

repeated, a tendency to dis-integrate in the future. Such a form of self-dysregulation may be at the heart of dissociation (Siegel, 1996).

The organization of attachment relationships may reveal characteristic ways in which the state of mind of the parent becomes linked to that of the child. For example, a securely attached child-parent relationship may have an ease in the creation of what can be called "dyadic states" in which the minds of two individuals become "joined" and function as a single adaptive and flexible system. Such a system can be seen as both highly integrated and highly differentiated in a manner that creates maximal complexity of the system's flow of states across time. This feature of complexity theory has profound implications at a number of levels. One implication is that integration occurs when there is a functional coupling of differentiated components. In the case of secure attachments, this coupling can be seen to allow for a balance in the patterns of regularity and novelty within the flow of states of the pair that enables the achievement of maximal complexity. Such a balance is observed as "attuned" or contingent communication and from this complexity view can be said to allow the system to achieve the most flexibility and stability.

For the disorganized attachments, a child may have experienced abrupt shifts in state on the part of the parent that can result in fear and disorientation in the child's mind. The hypervigilant stance seen clinically in these children may also reveal highly coupled communication with poor differentiation that may be seen as minimizing the level of complexity achievable by the dyad. The parent seems unable to perceive distress in the child and is thus unable to provide interactive regulatory experiences that would enable the child to use the parent to enter more tolerable levels of arousal. As mentioned above, repeated experiences within disorganized attachments have been shown to be associated with the process of dissociation in which mental processes fail to become integrated into a coherent whole (Main and Morgan, 1996, Ogawa et al, 1997, Carlson, 1998).

INTEGRATION

The interweaving of findings from attachment research, complexity theory, and neurobiology yield some intriguing possibilities. One idea is that the mind functions as a system that develops the ability to self-organize utilizing the modulation of both internal and external constraints. Internal mechanisms include neuromodulatory processes that enable the mind to regulate its states of activation, representational processes, and behavioral responses. Such a well-developed capacity for neuromodulation would be mediated by circuits capable of integrating a range of neural processes, from abstract representations to bodily states. As we've discussed, these circuits may confer "value" to stimuli and are functionally connected to the systems that mediate interpersonal communication.

"Integration" can be proposed to be a central self-organizing mechanism that links these many disparate aspects of internal and interpersonal processes. Integration can be defined as the functional coupling of distinct and differentiated elements into a coherent process or "functional whole." This concept has been used by a wide range of researchers including those studying group behavior ("inter-individual integration"), development across the lifespan ("individual integration"), and brain functioning ("neural

integration"). Within a coherently integrated process, adaptive and flexible states are achieved as individual components remain highly differentiated AND become functionally united. Such states may also be seen as moving toward conditions that maximize complexity. Coherent narratives and flexible self-regulation may reflect such an integrative process within the individual mind. Interpersonal integration can be seen when the mind of one person has the free and collaborative exchange of energy and information with another mind. Such adaptive and flexible states flow between regularity and predictability on the one hand, and novelty and spontaneity on the other, to yield a maximal degree of complexity in their functional coupling. Such dyadic states may be seen within the interactions of securely attached children and their parents. The "mind" – defined as the flow of energy and information – can thus be conceptualized as an inherently integrating system. This "system" may be viewed from a wide range of levels of analysis, from groups of neurons to dyads, families, and even communities. Such a view may allow us to synthesize our understanding of the neurobiology of the individual brain with insights into the interpersonal functioning of people within dyads and larger social groups.

Another application of the concept of integration can be seen in unresolved trauma or grief. Unresolved states may be conceptualized as an ongoing impediment of the mind to achieve coherent integration. Lack of resolution thus implies a blockage in the flow of information and energy within the mind and may also manifest itself as an impairment in the capacity to achieve a coherent transfer of energy and information between minds. This may help us to understand the finding that the most robust predictor of disorganized attachment is a parent's unresolved state of mind as revealed in the adult attachment narrative. One example of this 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, such as emotions, behaviors and perceptions, in the absence of an explicit memory counterpart for aspects of past traumatic experiences (Siegel, 1995). Such "dis-associations" of mental processes may be at the core of clinical "dissociation" and an outcome of both trauma and earlier histories of disorganized attachments.

A further application of the concept of integration can be seen in an analysis of the nature of our life-stories. The structure of the narrative process itself may 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" integration which enables many functions to occur, ranging from perceptual processes to motor coordination. Another process that can be proposed to depend upon bilateral integration is that of coherent narrativization. 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 of the brain is the social cognition or theory of mind 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 the capacity 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.

Perhaps impediments to this central process of the mind's capacity for integration, both internal and interpersonal, are at the core of the deficit in unresolved traumatic experience. Perhaps such an integrative capacity is at the heart of mental health. Finding ways to facilitate an integrative process within and between individuals may enable us to help others grow and develop.

INFORMATION PROCESSING AND THE RESOLUTION OF TRAUMA

This second part of the chapter will explore some ideas about information processing and the resolution of trauma that may be specifically relevant to the mechanisms underlying the effective treatment of individuals with unresolved trauma, and specifically to the method of psychotherapy employed in EMDR. As Francine Shapiro has noted, the name, "eye movement desensitization and reprocessing" is more reflective of historical thinking rather than the mechanisms of action of the method utilized in EMDR. Its name remains, however, as a function of common usage and general familiarity. Shapiro has suggested that the fundamental process that may be at the root of EMDR's effects is a form of "accelerated information processing" (AIP). The nature of EMDR's efficacy and specificity, the essential components, and the exact ways in which the method works each need to be examined carefully in controlled research paradigms. From the information processing perspective, EMDR may be a method that utilizes basic aspects of mental functioning that may be present in a number of other forms of effective psychotherapy. For this reason, the emphasis in this chapter will be on the notion of AIP as harnessed in the method within EMDR, but which may be already present in a number of effective approaches, such as CBT, and that may also be incorporated and further elaborated in existing as well as future approaches to the psychotherapy of traumatized individuals. This chapter will discuss a conceptual framework, based on the interpersonal neurobiological view presented above, that may apply to the interconnections among information processing in the brain, the impact of trauma, and the mechanisms of action of psychotherapeutic intervention. These are "hunches" about information processing, neurobiology, and the resolution of trauma that will need to be validated by specific research in the future.

INSIGHTS FROM THE ACADEMY

Before we begin discussing the following possibilities regarding the mechanisms of trauma and its resolution, it may be helpful to take a step back from these issues and examine some general principles of clinical practice. At a recent combined annual meeting of the American Academy of Child and Adolescent Psychiatry and the Canadian Academy of Child Psychiatry in Chicago, several educational sessions highlighted the importance of a set of perspectives on how a clinician comes to understand and make decisions regarding what therapeutic strategies to undertake in trying to help patients. One of these sessions was an Institute on Advanced Pharmacology: Contemporary Issues in Clinical Care (Wilens, 1999) and included a range of the most current thinkers in the research and practice of how to treat children and adolescents with various significant psychiatric disturbances, ranging from attention deficit, mood, Tourette's, Obsessive-Compulsive, Bipolar, Anxiety and Thought disorders. Many of these leaders in the field examined some basic principles of clinical care that are parallel, I believe, to some of the controversies in the field of treatment of

trauma. I will outline them here in the hopes of examining some of these general issues in a somewhat distinct field that are relevant to the issues of this chapter, and this topic.

1) Risk/Benefit Analysis: The decision to treat with a certain modality or strategies needs to always assess the potential risks and benefits of a particular approach.

2) Scientific/Clinical Rationale: Decisions to treat, or not to treat, with specific approaches should incorporate the latest in scientific understanding of the mechanisms of action and clinically demonstrated efficacy and safety of particular approaches.

3) Statistical versus Individual Tailoring of Therapeutic Approach: Carefully controlled studies examining the statistical probability of treatment response and treatment side effects need to be carried out and guide treatment choices whenever possible. Placebo-controlled, double blinded studies are extremely important to determine the elements of a treatment that may be producing clinical response.

4) Often we may only be able to hypothesize the possible mechanisms of action of certain therapeutic agents and pursue study of their specific modes of action. Clinical approaches may work even if we do not know the exact mechanisms of action of a particular approach.

5) Clinical decisions may require that the individual patient be considered in the face of statistical analyses about the "generalized patient." This situation holds for the occurrence of unusual side effects, as well as both positive and negative treatment outcomes that were not predicted by standardized studies.

The example of the use of antidepressant medications in preadolescent children helps to illustrate some of these points. It had long been known that these medications were extremely helpful in the adult population for treating major depressive disorder. Use of these medications in the adolescent population and in preadolescent children was carried out using the simple logic that if it works for older individuals, it will likely work for younger ones. This generally proved to be true for the adolescent group, but not for the younger patients in carefully designed studies. With this repeated finding, child clinicians were faced with a dilemma: do they subject children to the unknown side effects of medication treatment in the face of no improved response over placebo? Generally, clinicians are advised to attempt other forms of treatment, including the cognitive behavioral (CBT) and interpersonal (IPT) approaches as well as other forms of psychotherapeutic interventions, such as family therapy. In some cases, however, children do not respond to these methods, and the clinician is often forced to consider alternative treatments. As is the practice in the thoughtful clinical community, and as is advised by our research clinician leaders in the field, sometimes the clinician must choose the use of a treatment modality for an individual even in the face of the finding that in grouped statistical samples there has been no improved efficacy over the control group. And fortunately, for some of these children, such interventions seem to work to alleviate their suffering.

This example illustrates a general principle: we must endeavor to have carefully controlled studies to understand what works for whom, but sometimes clinical decisions must embrace the fact that necessary statistical procedures in these studies may

actually eliminate our awareness of particular individuals or situations that would indeed benefit from these approaches. The same may be true in the treatment of trauma. Some individuals may not need a particular intervention, but a minority may benefit immensely from it. As trauma may have unique impacts on the mind depending upon its timing in the development of the individual, we may expect to see marked differences in the effects of overwhelming stress on the developing brain. For example, De Bellis and colleagues (1999b) have demonstrated impaired development of specific regions of the corpus callosum in abused children – but did NOT show effects on the hippocampus as found in studies of individuals traumatized later in life. This finding may be important in revealing that "traumatized individuals" may have quite distinct patterns of subsequent effects that may require different aspects of treatment to produce efficacy.

Finally, we must keep in mind the importance of the "first do no harm" approach. We must weigh risk/benefit ratios carefully, always keeping in mind that there is a "risk" to no treatment. For some individuals, finding a treatment approach that may have statistically been "washed out" from having a statistically demonstrated effect should not automatically eliminate it from our therapeutic "doctor's bag" of possible agents to help our patients reduce their suffering. As the efficacy studies demonstrate, both CBT and EMDR may be effective methods of treatment of individuals with PTSD. As initial dismantling studies reveal, the sensory stimulation component of EMDR may be unnecessary for a positive treatment response in many individuals. Knowing how the non-sensory components of the EMDR method, as well as the mechanisms of CBT, help patients to heal can only help us understand how to treat our patients. In some individual cases, however, use of the sensory stimulation may be found to improve the efficacy of treatment in situations where therapeutic progress has become "stuck" and the patient requires an individual tailoring of approach, as is faced in the preadolescent population with significant disturbances of mood. We should endeavor to keep an "open clinical mind" to the importance of clinical research and of these principles of clinical care as we work to understand and help our patients heal.

UNRESOLVED TRAUMA

The discussion in the first part of this chapter suggests that traumatic experience impacts the individual by overwhelming the innate capacity of the mind to respond to stressful events. "Overwhelming" implies that the ability of the brain to process the incoming data becomes impaired: information and energy (the essence of mind) flow within the brain in a manner which leads to a dysfunction in the movement toward maximizing complexity. Excessive response of the brain with the release of "stress hormones" and other chemicals, such as the catecholamines, norepinephrine and epinephrine, can produce deleterious effects on the functioning of a number of systems in the brain (De Bellis et al, 1999a and 1999b). Among these are the medial temporal lobe with the hippocampus, which may be especially susceptible to transient and to long-term impairment to high levels of cortisol. For example, individuals with chronic PTSD have been found to have hippocampi with smaller volumes than control subjects (Bremner and Narayan, 1998). The impact of overwhelming stress on this system may be to inhibit the processing of explicit memory in the setting of intact implicit encoding. As discussed, this may be at the heart of "dissociative" reactions to stress and may be

mediated by specific impairments in the neural circuits that integrate information within the brain.

Overwhelming events, that is, traumatic experiences, may also produce more global effects on the mind. Such effects can be seen either in excessively restrictive and controlled states of mind; or, in contrast, as chaotic and disorganized states. Patterns in the flow of energy and information that become ingrained as these restrictive or chaotic states reveal a lack of resolution of trauma. As we've discussed, such an impairment in the system's movement toward complexity directly interferes with its ability to adapt to changes in the internal or external environment. Such impaired flexibility leads to dysfunction in both the internal and interpersonal worlds of the individual.

Lack of resolution of trauma can be seen as an impairment in the innate capacity of the mind to integrate energy and information flow. Integration can be defined as the functional clustering of independent subcomponents into a cohesive whole at a given moment in time. Integration also exists across time, and can be described as enabling the mind to achieve coherence across its many states of mind. Within the brain, neural integration can involve a wide range of layers of components, including clusters of neurons, neural circuits, systems, and hemispheres. With names such as vertical, lateral, dorsal-ventral, and spatiotemporal integration, the nature of this neural process can be described in quite specific detail. At the core of neural integration is the process called emotion. Emotion is inherently integrative: it links subcomponents together in a functional whole. Emotion is also a fundamental part of self-regulation. In this manner, we can see that the proposal that unresolved trauma exerts its effects by an impairment of integration implies that lack of resolution is a form of self-dysregulation and emotional disequilibrium. Integration, self-regulation, and emotion are thus inextricably intertwined neural processes that are impaired in unresolved traumatic conditions.

THE RESOLUTION OF TRAUMA

By this discussion, one can see that the general approach to psychotherapy for individuals with unresolved trauma would be to attempt to enhance the mind's innate tendency to move toward integration, both within the brain and within interpersonal relationships. The measure of efficacy for such an approach would be an enhancement in self-regulation and emotional processing. In addition to the dissolution of the many and varied symptoms of posttraumatic stress disorder, we could also predict a number of other fundamental changes in the individual's functioning. From a system's perspective, therapeutic improvement would be revealed as a more adaptive flexibility of the mind to respond to changes in the internal and external environment. Stability of mood would replace emotional lability. Increased capacity to experience a wider range and intensity of emotion would emerge with an enhanced tolerance for change. Resolution would also be revealed as a movement of the individual toward more differentiated abilities while at the same time participating in more "joining" experiences. This increased individual differentiation and interpersonal integration would reflect the mind's movement toward increasingly complex states. Overall, these changes would reflect not only the freedom from posttraumatic symptomatology, but the enhanced capacity of the individual to achieve integration (internal and interpersonal) and thus more adaptive and flexible self-regulation.

One outcome of this enhanced integration would be revealed within more coherent autobiographical narratives for specific traumatic events as well as for the life of the individual as a whole. Such a narrative process can be seen in both the personal

stories that are told, as well as the ways in which the individual's life is lived. This latter aspect, called "narrative enactment," would be seen as the manner in which life decisions are made and the quality in which daily life is experienced.

THE INTERPERSONAL EXPERIENCE OF PSYCHOTHERAPY

In general, psychotherapy can be seen as a form of attachment relationship in which the patient seeks proximity to the therapist, has a safe haven (is soothed when upset), and achieves an internal working model of security based on the patterns of communication between therapist and patient. Healing within psychotherapy can thus be seen as the ways in which the innate, hard-wired attachment system of the brain is utilized to enable the patient's mind to achieve more functional self-regulation. As with attachment in general, interactive regulation is first required to enable the mind to achieve more autonomous (and adaptive) self-regulation. The patterns of communication that have been found to be the most effective in secure attachments are those that involve reciprocal, contingent, collaborative communication. This involves a give-and-take of signals between the two members of the interacting pair. Right-to-right and left-to-left hemisphere patterns of communication can be described, involving nonverbal and verbal components, respectively.

At the core of effective therapy of many forms may be the manner in which patient and therapist are able to engage in collaborative communication. For individuals with unresolved trauma, this therapeutic attachment relationship enables the patient's mind to enter terrifying states that can then process information that before may have led to excessively restrictive or chaotic patterns in the flow of energy and information. These rigidly constrained or disorganized states, at the core of unresolved trauma, can then have the opportunity within this interpersonal communicative experience to be dramatically – and permanently – altered. Note that the essential feature is not that all of the details of trauma be related with words, but rather that the patient be given the sense of safety that such traumatic states can be re-experienced, communicated if possible, and altered into more adaptive patterns in the future. What emerges from such a process are new levels of integration of information and energy flow. If such a process involves the bilateral integration of information across the hemispheres, an increased coherence of autobiographical narratives may result. Note that the creation or communication of such a narrative may not be essential for resolution, but rather may reveal resolution.

ACCELERATED INFORMATION PROCESSING AND EMDR

EMDR as a method contains very specific elements which may be essential for it to enable patients to achieve resolution of trauma. As Francine Shapiro has stated, if EMDR were just about moving the eyes back and forth, people would just need to turn on their windshield wipers and their traumas would be resolved. Instead, EMDR, as with any method of effective psychotherapy, involves quite specific elements that build on the interpersonal setting described above. In this section, I will highlight some of the specific component elements of the EMDR approach and propose some neurobiological mechanisms that may be at work. As discussed repeatedly above, these suggestions are "hunches" that will require careful research to clarify their validity. Investigations exploring which elements of EMDR are essential for effective outcomes is also an area of study that may help elucidate the mechanisms of the resolution process.

Focal Attention

When a therapist asks that a patient "think about. . ." something or "put that image in the front of your mind," she is requesting that the individual activate a process called "focal attention." Our knowledge of this form of intentional, conscious attention is that it focuses a kind of "attentional spotlight" on a set of representations activated at that moment in time. Focal attention appears to be a part of the "working memory" process, considered to be the "chalkboard of the mind." Working memory is thought to be mediated by a number of circuits, especially the lateral prefrontal cortex and the anterior cingulate. Representations activated at a given moment are thought to be "linked" to the activity of these regions. The "conscious" component of working memory may involve a range of elements, including the thalamocortical system and its forty cycle per second (40 herz) sweep of activity across the brain (Llinas, 1990). Another view of consciousness is that when a critical level of integrative clustering occurs, representational processes become a part of conscious awareness (Tononi and Edelman, 1998). Damasio has also presented a view of consciousness (Damasio, 1999) that examines the ways in which the brain creates neural maps that represent the response of the self in its interactions with objects in the internal or external world. Focus on the "object" results from an enhanced neural mapping of the entity interacting with the self. As discussed earlier, this sense of "core consciousness" is intimately interconnected with the creation of emotion. We can see here that emotion can be seen as an integrating neural process that emerges as we engage our selves with the world (inner or outer). Each of these perspectives may help explain different aspects of consciousness and focal attention. For this chapter, we will utilize a view that involves the lateral prefrontal cortex, a 40 Hz thalamocortical sweep, representations of the interacting self, and the achievement of a certain level of functional clustering (integration) within the binding of representational processes into consciousness.

The involvement of focal attention appears to be a requirement for the processing of information into explicit memory. Such a process involves the hippocampus for initial encoding into long-term memory. As discussed above, this process may have been impaired in unresolved states. Thus, therapeutic use of focal attention on images of trauma are no casual thing: Involving the representations of these past experiences, and the states of mind associated with them, with the process of focal attention can by itself begin to open up the doors to new forms of information processing.

The therapeutic focus of attention on multiple layers of representational processes, including images, emotions, bodily sensations, global linguistic statements, and perceptions generated from recollections, is a unique and important process. This "multilayered focus of attention" produces a new configuration of information processing within the brain. By doing so, such a therapeutic strategy leads to a new associational matrix of these varied representational elements. Within the setting of a secure, empathic therapeutic relationship, such a multilayered process enables new memory associations to be created. This new combination may be essential for unresolved memories of trauma to move toward consolidation (and resolution): a process that likely involves the integration of memory representations that before had remained isolated within the unresolved traumatic state.

Orientation, Arousal and Appraisal

One of the first components of an emotional response can be described as the orientation of the mind to a stimulus and its representations in the brain. By having a

patient focus attention on an image, on his emotions, on his bodily state, and on his negative self-cognitions, the therapist engages a multilayered focus of attention and is activating the essential components of emotional processing. This is also no casual event: Emotion, as we've discussed, is intricately interwoven with the brain's capacity for integration and self-regulation. Within the EMDR approach, the multilayered and densely focused process of activating each of these elements may be especially powerful in a number of ways. These attentional processes may involve an array of functionally differentiated elements of cognitive processing, some of which may have been dis-associated within the unresolved trauma condition. These representational processes may also have anatomically distributed sites that mediate their function. An autobiographical image is likely generated from the posterior regions of the right hemisphere. The focal attention on "feelings" may also be primarily mediated by the right side of the brain as they are activated from various subcortical regions such as the amygdala and hypothalamus. The "body scan" encourages the patient to check the status of the body, an ability which has been shown to be more highly integrated in the right hemisphere via a "somatosensory system" that registers (and regulates) the homeostatic state of the chemical milieu, internal body organs (such as lungs, heart, intestines) and the changing state of the skeletal system musculature. The somatosensory system is thought to involve a range of subcortical and cortical areas, especially the orbitofrontal and anterior cingulate regions (Damasio, 1999). The request that a patient state in words a self-cognition, negative or positive, probably involves complex layers of mental models and specific elements of autobiographical memory as they become linked to the left hemisphere's semantic memory and language processing centers. Such a process produces a "fact about the self" as viewed from a self-standpoint. The focusing of attention on all of these elements may thus involve the lateral prefrontal cortex, anterior cingulate, orbitofrontal, and thalamocortical circuit on each side of the brain.

The movement of the eyes from side to side may also directly activate the attentional focus of the basic orientation response (Corbetta et al 1998). Other forms of alternating sensory stimulation, as in auditory or tactile means, may also serve to orient attention. Whether these specific mechanisms of activating attention within EMDR are actually necessary or a part of a more generalized process of orientation and the initiation of emotional response needs to be clarified in future research. Note that in unresolved traumatic states these various representational processes may have remained quite functionally independent, an isolation that may have preserved the ability of the individual to function in the face of traumatic experiences. Now, perhaps for the first time, these representational processes are being activated within the brain simultaneously. This simultaneous activation will be occurring at the same time as the initiation of focal attention within these orienting processes. Such a "synchronic" activation may be necessary, but not sufficient, to begin the process of neural integration. This representational situation of multilayered focal attention does not by itself necessarily lead to a lasting a form of integration. The nature of the processing that occurs during the simultaneous activation of these previously functionally isolated representational processes can make a significant difference in the direction of information processing and therapeutic outcome.

In the model of emotions described in The Developing Mind, the process from initial orientation (of attention) to subsequent arousal and appraisal of the mental representations is the essence of "primary" emotional states. These primary emotions are the "background" emotional processes (Damasio, 1999) that serve as the initial patterns of activations that then may become elaborated into more complex ("specific"

or categorical) emotions. Primary emotions, reflected in the profiles of energy activation within the brain, are at the core of how the mind evaluates the significance and meaning of a stimulus. These are the initial aspects of emotional processing. The neural mechanisms underlying this process are proposed to involve neuromodulatory circuits discussed earlier that have a number of properties: 1) they increase the excitability and activation of neurons; 2) they enhance neural plasticity via the growth of synaptic connections, 3) they are widely distributed throughout the brain and enhance integration through their extensive enervation of distinct brain regions; and 4) they are thus fundamental to self-regulation.

The fundamental role of emotion in all aspects of mental life can be seen within the processes by which therapy focuses the patient's orientation toward a particular set of representations. This focus of attention then influences the direction of the "emotional" processing of the varied layers of subjective mental life, from ongoing perceptions to autobiographical representations. As initial orientation is followed by the arousal/appraisal process, a sense of hedonic tone may unfold in which there is an internal sense of good/approach or bad/withdrawal. As the process emerges, these primary emotional states may become elaborated into the categorical or universal emotions of fear, sadness, anger, joy, surprise, disgust and shame. Such internal states may be apparent as externally expressed affect. Whatever the level of external communication, the patient's internal experience of these emotional states reflects the subjective core of the flow of information processing and the achievement of new levels of integration as therapy proceeds. In this manner, effective psychotherapy can be seen fundamentally as an emotionally engaging and transformative experience that enables new levels of representational integration to occur. Recall that emotion is inherently integrative. In this manner, one can see how impaired integration, as reflected within emotional dysregulation present in unresolved states, may move toward balanced self-regulation as the emotionally involving therapy progresses.

States of Mind

The simultaneous clustering of functionally distributed representational processes enables the brain to achieve a particular state of mind. In unresolved trauma, a particular activation of elements within focal attention may create a semi-stable state – usually nonconsciously avoided or intrusively flooding and disabling outside of therapy – that can now be a primary focus of treatment. The brain is now being "primed," that is being made more likely, to activate new associations of representational processes. In fact, the therapist's strategic clustering of these elements (image, feeling, bodily sensation, cognition) creates a unique state of mind that may enable new directions of information processing to occur. The impediments to the acquisition of these new forms of processing, as we've discussed above, can be proposed to be embedded in either an excessively restricted, rigid pattern in the flow of states, or a chaotic, flooding and disorganizing flow of states. Either condition has led to an impairment in the adaptive, flexible response to internal or external factors. Such inflexibility is the greatest challenge at this moment in therapy. This inflexibility may be at the foundation of the "getting stuck" or "going blank" that may have occurred in the patient's life, as well as in moments within the therapy process itself. Such "stuck" points can be seen as the emergence of the rigid patterns of the flow of information processing and energy in the brain. They are ingrained patterns in dire need of change.

One way in which these past stuck points can be altered is that these new multilayered simultaneous activations within focal attention/working memory contain within them intense emotional elements that are potentially open to change. The setting of a secure patient-therapist relationship may create a sense of safety that allows the discomfort, anxiety, fear or outright terror to become more tolerable. Within the sensory stimulation sets themselves (eye movements, sounds, tactile stimulation), many have described a "relaxation response" in which they feel a calming, tranquil sensation that seems to be induced directly from the bilateral stimulation. An informal assessment of non-bilateral alternating sensory stimulation (tactile sensation on one side of the body only or vertical rather than horizontal movement of the eyes) and non-alternating stimulation (focusing on a stationary object) does not produce the same sense of focused attention or relaxation. If this finding is systematically found to be generally true under more controlled research conditions, then perhaps the bilateral stimulation in the setting of a therapeutic relationship each may contribute to enabling the patient to experience focal attention to these traumatic elements while simultaneously having the intensely negative affective component be soothed to some degree. The overall effect would be to enable multiple layers of focal processing, alter the subjective experience of the state of mind, and enable such states to be better tolerated. The re-encoding of these representational elements in this setting of less distressful affect would then allow for a less distressing emotional charge to become associated with the "reconstructed" memory representation. Future retrieval would then reveal such a newly reorganized memory configuration which, in turn, would be more easily tolerated. The repeated process of such activation, multi-layered focal attention, encoding, re-activation, encoding, etc., would modify the memory into a more tolerated, integrated, and perhaps "resolved" configuration that no longer had such devastating effects on the flexibility of the system's flow of states.

Bilateral Stimulation

In addition to the possible relaxation response described above, the effects of the alternating and bilateral stimulation used within EMDR may have both general as well as quite specific effects on the processes of the mind that facilitate the resolution of trauma within certain individuals. "Dismantling studies" are important in attempting to delineate which aspects of a therapeutic method may be essential for positive outcomes in the pooled groups of subjects necessary for statistical analysis. Though early dismantling studies may demonstrate that one or another aspect of a technique are not necessary for an overall statistically significant improvement in patient status, as discussed earlier in this section, it is important to keep an open clinical mind as to more subtle aspects of an approach that may directly mediate improvement in the subjective experience of a given individual – benefits that may be more difficult to quantify or that may be lost in pooled statistical analyses. Further research needs to clarify if the form of sensory stimulation utilized within EMDR truly adds some specific benefit to the therapeutic process – and if so, with which patients does it appear to be effective. If alternating stimulation is in fact beneficial for a given patient, we need to address whether its bilateral nature is important. If it turns out to be that the alternating and the bilateral aspect of the stimulation do provide either qualitative or quantitative benefits for certain individuals, such as internal sense of relaxation, faster speed of resolution, or other less quantifiable aspects of the therapeutic process, then the following proposed mechanisms may be possible explanations of how the bilateral stimulation may work in those situations.

As described in the first half of this chapter, we can propose that the traumatic impairments to neural integration have many layers of effects. One layer is on the isolation of the representational processes of the right and left hemispheres. These two regions have asymmetries in the developing embryo that give rise to quite distinct modes of constructing reality (Tucker, Luu and Pribram, 1995; Trevarthen, 1996) . In reviewing a range of research findings from laterality studies, emotion, and memory, I have offered the proposal, summarized earlier in this chapter, that the process of integrating the modalities from the left and from the right hemispheres enables traumatic memories to be processed in a new manner that enables resolution to occur. This process may be a component of the emotionally attuned communication and co-construction of narratives that are a foundation of a number of forms of therapy. In this manner, both non-verbal and verbal communication enable patient and therapist to "resonate" with each other in a fashion that begins to promote internal "resonance" or integration within each person's mind. The patient and the therapist are both impacted by the experience of psychotherapy. My own experience as a psychotherapist before learning about EMDR suggests that this proposed process of bilateral integration may be at the heart of resolution of trauma. Coherent narratives emerge from such an integrative process and can be proposed to reveal, as well as promote, the resolution of trauma. After recently learning EMDR and applying it in a few individuals' therapy sessions, it is my impression that the method enables achievements to occur in some situations in a more rapid manner. Certain patients became "stuck" with particular issues, and the use of EMDR in those cases seemed to help. EMDR is not some form of magic. It does, however, appear to allow for a highly focused form of integration to occur at an accelerated rate. For certain patients, at certain times, EMDR has been extremely useful. For others, the use of the sensory stimulation in my own experience has not been helpful and has actually been "distracting" to these patients. In a few cases who have had positive responses, when I have had the opportunity to try non-bilateral or non-alternating sensory stimulation, the sense of relaxation and focus described by these patients was no longer present. These are clearly non-blinded, single case examples that do not qualify as scientific data. Nevertheless, they do reveal the subjective accounts of certain traumatized individuals undergoing treatment. We will need to await further carefully designed studies that may help us determine individual responsivity and in examining which elements of EMDR are essential for which patients.

My own sense of the role of the bilateral stimulation for certain patients is that it enables fixed or chaotic states to achieve new levels of integration that foster rapidly re-organizing patterns in the flow of states across time. One view of development is that it involves the organization, dis-organization, and re-organization of patterns in the flow of states of mind. In this manner, development requires periods of disequilibrium in order to move forward in its ever-changing trajectory. In unresolved trauma, such forward movement has stopped. Restrictive or chaotic states preclude adaptive development from occurring. Therapeutic interventions that create new associations of representations related to traumatic experiences are a first start. Enabling more global changes in the flow of states across time based on these representational activations is one aspect of change that I propose the bilateral stimulation may be catalyzing. Such bilateral integration may indeed occur within emotionally attuned, co-constructing therapeutic relationships without any use of "sensory stimulation". Bilateral sensory stimulation may accelerate the therapeutic acquisition of new levels of neural integration and the resolution of trauma.

Within EMDR, the bilateral stimulation sets can be proposed to instantiate a simultaneous autonoetic retrieval (right) and encoding (left) state (Tulving et al, 1994).

Such a readiness for re-organization of memory processing has been prevented by the unresolved condition. REM disturbances and nightmares may reflect this impairment. As the elements of multilayered focal attention (image, feeling, body, thought) prime the system, the rhythmic activation of left and right hemisphere (possibly stimulated by eye movements – eyes to left activates the right brain and vice-versa – or alternating auditory or tactile stimulation) enables the inherent encoding and retrieval states of each hemisphere to directly alter the experience of autonoetic consciousness. This proposal is based on the suggestion that sensory stimulation (sounds, tactile sensations) or motor activity (eye movements – not what the eyes are seeing, but the activation of the cranial nerves necessary for their motion via the extraocular muscles) are associated with activity in the opposite side of the brain (Kinsbourne 1972, 1974). This possibility, for example, is supported by the general finding that people look to the left when retrieving autobiographical memory (known to activate the right hemisphere – especially in the orbitofrontal and posterior regions of the cortex) (Wheeler, Stuss, and Tulving, 1997). As the sets continue, the notion that the patient is experiencing the observation of memory "as if a passenger on a train watching the scenery go by" is quite consistent with our knowledge of autobiographical memory. We have the ability to have "observer" or "participant" recollections, possibly reflecting our noetic and autonoetic reflections on personally experienced events, respectively. Some suggest that the noetic, semantic or factual elements of memory are stored predominantly in the left hemisphere, whereas autobiographical (the sense of the self in the past, not merely the knowledge of such an experience) representations are stored in the right hemisphere. As discussed earlier, flashbacks appear to involve the intense activation of the right hemisphere (visual cortex) in the setting of left hemisphere (speech area) deactivation. In this manner, the bilateral stimulation sets may "force" the activation of both hemispheres in the therapeutic process of integrating autobiographical and semantic representations of traumatic events. For some patients, the therapeutic technique of facilitating the synchronous process of representational activation involving the circuits of each hemisphere (as discussed above) may be sufficient to produce excellent results and the use of bilateral sensory stimulation may be unnecessary. In some cases, the bilateral stimulation – especially the process of eye movements with the eyes open – may actually hinder the capacity to visualize important mental images. In this manner, bilateral integration may be at the heart of resolution, but the therapeutic strategies necessary to achieve it may vary depending on the particular needs of a given individual.

Bilateral activation induced by the psychotherapeutic process of encouraging representations from both sides of the brain – with or without sensory stimulation as an aid – seems to evoke a noetic/autonoetic encoding and retrieval state that enables memory to be processed in an accelerated fashion. As the structure of memory may be layered by a wide range of explicit components, such as periods of life, thematic elements, specific experiences, and evaluative components, as well as the implicit elements of emotion, behavioral impulse, perception and bodily sensation, the therapeutic processing of traumatic memory may come to involve the integration of a wide array of mental processes. These activated representations can then be functionally linked to each other in truly new combinations that are likely mediated by the creation of new synaptic linkages. Effective therapy does not only involve an intensely emotional experience in the moment, but probably involves lasting changes in brain structure and function.

Central in the encoding and retrieval of autobiographical memory appears to be the region of the prefrontal cortex we've discussed at length earlier in the chapter: the

orbitofrontal cortex. As a region of the brain in the unique position of receiving and sending input from and to a wide range of important regions, such as the association cortex, the limbic regions, and the autonomic nervous system via subcortical circuits, the orbitofrontal cortex can be proposed to play a crucial role in neural integration. The findings that this region is essential in attachment, autobiographical memory, representation and regulation of bodily state, social cognition, and the expression and regulation of emotion, highlight the probable importance of this area in the resolution of trauma. The ways in which the brain comes to modulate states of mind in a more flexible manner, to tolerate a wider range of emotional states, to gain access to and consolidate autobiographical memory, and to enable more complex levels of interpersonal relatedness may each be mediated in large part by this region of the brain. When we look to the mechanisms of resolution of trauma as being rooted in neural integration, we may be well advised to look toward the integrative orbitofrontal region in mediating the acquisition of mental coherence.

RESOLUTION: RESPONSE FLEXIBILITY, AUTONOETIC CONSCIOUSNESS, AND INTEGRATION

In The Developing Mind, I suggest that the term "response flexibility" can be used to describe an important integrative process also mediated by the orbitofrontal region. 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 (Nobre et al 1999, Mesulam, 1998). One can propose that this ability requires the integrative capacities of the orbitofrontal region in order to functionally link elements from widely distributed input and output circuits. As discussed earlier, this region is uniquely positioned to link the major regions of the brain, including the associational cortex, limbic circuits and brainstem areas. In this manner, the orbitofrontal region enables the more complex "higher order" processing of the neocortex to be integrated with the "lower order" 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 such a "lower mode" (or, as some of my patients have preferred to call it, a "low road") of processing, 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 effect of trauma is to make such a lower mode of processing more likely to occur. While each of us may be vulnerable to entering such states given the "proper" stressful situations, unresolved trauma may make entry into such states more frequent, more intense, and more likely to occur with minimal provocation. Recovery from such states that have moved beyond a "window of tolerance" may also be especially difficult in unresolved traumatic conditions. In this situation, the individual may remain "on the low road" for more extended durations as well as with increased frequency.

The neurobiology of such a lower mode of processing can be proposed to involve the state dependent inhibition of the orbitofrontally mediated neural integration of neocortical input with that of the limbic and brainstem regions of the brain. Such a state

may be present, we can propose, in flashback conditions as well as in intense emotional responses to trauma-related stimuli from the external or internal environment. Entry into such states can 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. Interpersonally, the entrance into such states directly impairs the capacity of the individual to maintain collaborative communication. In this way, the tendency to have an impairment in response flexibility and autonoetic consciousness 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. Herein may lie the core elements in the intergenerational transfer of trauma as its devastating effects leave a wake of pain across the boundaries of space and time that separate one mind from another.

As psychotherapeutic interventions promote neural integration, we can imagine that the integrative orbitofrontal region may become more actively involved in the global functioning of the individual. We can also propose that this outcome would be especially evident during the activation of representations related to traumatic memories. In unresolved states, trauma-related stimuli may activate a cascade of mental representations that produce an inhibition of response flexibility and autonoetic consciousness. As discussed earlier, this impairment may take the form of either excessively rigid or of disorganized patterns in the flow of states of mind across time. In this way, the blockage of orbitofrontally mediated integration during trauma related conditions may be the mechanism of impaired flexibility of response. Resolution would thus involve the repair of such impediments to flexible self-regulation.

Psychotherapeutic processes may facilitate the resolution of trauma by altering the constraints on the flow of states of mind within the individual. At the most basic level of analysis, this alteration in the pattern of neural firing is likely to be mediated by changes in synaptic strengths among widely distributed neurons in the brain. These changes may be especially evident in the function of the neuromodulatory circuits. The growth of new synaptic connections as well as of neurons themselves may be revealed with the integrative fibers of regions such as the hippocampus that have been recently shown to develop throughout the lifespan (Benes, 1998). We might also want to look toward the corpus callosum, cerebellum, and the anterior cingulate as other integrative regions that may respond positively with new development as a result of effective treatment and the resolution of trauma. The more global effects of resolution would be seen in how the mind functions as a complex system, now allowing for the more complex flow of energy and information within itself and in connection to other minds. Such a healing process is thus far more than the modification of the degree of distress associated with traumatic memories. Instead, the resolution of trauma can be viewed as enabling the mind to regain the natural process of integration across time and across states of mind. Successful resolution creates a deep sense of coherence within the individual. Enhanced autonoetic consciousness would be the outcome of such a resolution process and revealed as a more flexible capacity of the individual to reflect on the past, live fully in the present, and have an active sense of the self in the future. This new level of mental coherence can be revealed within autobiographical narratives that "make sense" of past experiences and their impact on present functioning as well as allowing the mind to create a sense of hope for the future. An individual moves from being the passive victim of trauma to the active author of the ongoing story of his or her life. Integrating coherence, though, is not a final achievement. Rather, it is a process

that enables the person to engage in the spontaneous and flexible flow of energy and information within the mind, as well as within meaningful and invigorating connections with others.

REFERENCES and SUGGESTED READING

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

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

-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.

-Bjork, R. (1989). Retrieval inhibition as an adaptive mechanism in human memory. In H.L. Roediger & F.I.M. Craik (Eds.), Varieties of memory and consciousness: Essays in honor of Endel Tulving, (pp. 283-288). London: Wiley.

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

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

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

-Corbetta, M., Akbudak, E., Conturo, T.E., Snyder, A.Z., Ollinger, J.M., Drury, H.A., Lineweber, M.R., Petersen, S.E., Van Essen, D.C. (1998). A common network of functional areas for attention and eye movements. Neuron, 21:761-773.

-Damasio, A. (1994). Descarte's error: Emotion, reason, and the human brain. New York: Grosset/Putnam.

Damasio, A. (1999). The Feeling of What Happens: Emotion and the body in the making of consciousness. New York: Harcourt Brace.

De Bellis MD; Baum AS; Birmaher B; Keshavan MS; Eccard CH; Boring AM; Jenkins, FJ; Ryan ND. (1999a). A.E. Bennett Research Award. Developmental traumatology. Part I: Biological stress systems. Biological Psychiatry, 45(10):1259-70.

De Bellis MD; Keshavan MS; Clark DB; Casey BJ; Giedd JN; Boring AM; FrustaciK; Ryan ND. (1999b) A.E. Bennett Research Award. Developmental traumatology. Part II: Brain development, Biological Psychiatry, 45(10):1271-84.

De Bellis, M. (1999c). "The neurobiology of trauma" Presentation at the 1999 Annual Meeting of the American Academy of Child and Adolescent Psychiatry, Chicago.

Edelman G (1992): Bright Air, Brilliant Fire. New York: Basic Books.

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

-Garber, J. & Dodge, K.A., (Eds) (1991). The Development of Emotion Regulation and Dysregulation. Cambridge: Cambridge University Press.

Hesse, E. (1999). The adult attachment interview: Historical and current perspectives. In: J. Cassidy & P. Shaver, (Eds.), Handbook of Attachment. Pages 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, volume 59. Pages 192-207.

Kinsbourne, M. (1972). Eye and head turning indicates cerebral lateralization. Science, 176, 539-541.

Kinsbourne, M. (1974). Direction of gaze and distribution of cerebral thought processes.

Neuropsychologia, 12(2):279-81.

Llinas, R.R. (1990). Intrinsic electrical properties of mammalian neurons and CNS function. Fidia Research Foundation Neuroscience Award Lectures, 4:175-194.

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

-Main M (1991): Metacognitive knowledge, metacognitive monitoring, and singular (coherent) versus multiple (incoherent) models of attachment: Findings and directions for future research. In: C.M. Parkes, J. Stevenson-Hinde & P. Marris (Eds), Attachment Across the Life Cycle. London: Routledge, pp. 127-159.

-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. Analytic Press: Hillsdale, NJ.

-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 (pp161-182). 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 7 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.

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.

-Rauch, S.L., van der Kolk, B.A., Fisler, R.E., Alpert, N.M., Orr, S.P. Savage, C.R., Fischman, A.J., Jenike, M.A., & Pitman, R.K. (1996). A symptom provocation study of posttraumatic stress disorder using positron emission tomography and script-driven imagery. Archives of General Psychiatry, 53, 380-387.

-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.

-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.

Siegel, D.J. (2001a). Toward an Interpersonal Neurobiology of the Developing Mind: Attachment relationships, "mindsight," and neural integration. Infant Mental Health Journal, Special Edition on Contributions of the Decade of the Brain to Infant Psychiatry, 22:67-94.

Siegel, D.J. (2001b) Memory, An Overview, With Emphasis on Developmental, Interpersonal, and Neurobiological Aspects. J Am Acad Child Adolesc. Psychiatry, 40:9, 997-1011.

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

Tononi, G. & Edelman, G.M. (1998). Consciousness and complexity. Science 282:1846-1851.

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

--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.

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

Whalens, T. (1999). Institute Chair, Institute on Advanced Psychopharmacology: Contemporary Issues in Clinical Care, 1999 Annual Meeting of the American Academy of Child and Adolescent Psychiatry, Chicago.other

-Wheeler, M.A., Stuss, D.T., and Tulving, E. (1997). Toward a Theory of Episodic Memory: The frontal lobes and autonoetic consciousness. Psychological Bulletin, 121, no. 3, 331-354.

[1] Lifespan Learning Institute, "Understanding and Treating Trauma", Marion Solomon, Ph.D., coordinator. Los Angeles, CA, January 1998.

[2] See Siegel 2001a, 1999a and b, 1996, 1995, The ideas in this chapter are derived from these publications and have been adapted from them and modified in parts froman in press chapter in Healing Trauma: Attachment, brain, mind, and body, Marion Solomon and Daniel Siegel, Editors, (WW Norton, 2002), and the summary of The Developing Mind found in the 1998 Signal publication, Volume 6, numbers 3-4, of the World Infant Mental Health Association.