HANDBOOK OF CHILD SEXUAL ABUSE
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CHAPTER 2

Child Sexual Abuse, Traumatic Experiences, and Their Impact on the Developing Brain

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INTRODUCTION

The U.S. Department of Health and Human Services documented that 3 million children were allegedly maltreated in 2007. Of these cases, more than 50,000 were suspected to have been sexually abused. The sexually abused children in the summary report were more likely female than male and 20% were under 8 years at the time of the assault. Forty percent of the assaults were perpetrated by family members ("Statistics Surrounding Child Sexual Abuse," 2008). It has been estimated that, in the United States alone, there are 39 million survivors of childhood sexual abuse ("Statistics Surrounding Child Sexual Abuse," 2008). The magnitude of this problem is enormous when one realizes child sexual abuse is just one of many co-occurring maladies in children's lives.

Child sexual abuse has commonly been viewed as if it were an isolated traumatic event, but nothing could be further from the truth. In fact, childhood sexual abuse seldom occurs as an isolated event. Rather, sexual abuse is more likely one adverse event coexisting among a host of other adverse circumstances in a child's life (Anda et al., 2006). Among the concomitant stressful events are physical and emotional abuse; parental psychiatric history; parental history of legal involvement; foster care; mental illness of a parent; parental marital discord; family history

of violence; and alcohol and drug use in the family. Evidence from neurobiology and epidemiology research suggests these early life adverse experiences cause long-term changes in multiple brain systems (Anda et al., 2006). Worse, increasing frequencies of early adverse childhood experiences in a child's life were highly correlated with enduring brain dysfunction and were also linked to deleterious effects on health and quality of life (Anda et al., 2006).

Van der Kolk (2001) found that the majority of people seeking care for trauma resulting from maltreatment suffered from multiple psychological problems between 75% and 98.6% of the time. This apparent comorbidity of psychopathology became a destructive experience impacting the developing child, increasing risk of emotional, behavioral, academic, social, and physical problems throughout the child's life span (Anda et al., 2006; Perry & Pollard, 1997, 1998; Spinazzola, Blaustein, & van der Kolk, 2005). Among the comorbid neuropsychiatric diagnoses associated with childhood trauma are major depression, dissociative disorder, oppositional defiant disorder, conduct disorder, dysthymia, obsessive-compulsive disorder, phobic disorder, PTSD, substance abuse, borderline personality disorder, attention deficit and hyperactivity disorder, various developmental disorders, schizophrenia, and ultimately nearly all *DSM IV* diagnoses (Perry, 2008). This observation leads trauma researchers to include sexual abuse as only one of a host of traumatic childhood experiences comprising a larger complex web of child maltreatment contributory to long-term dysfunctional emotional, behavioral, cognitive, social, and physical development, and health outcomes (Anda et al., 2006; Perry, 2008; Perry & Pollard, 1998; Spinazzola et al., 2005; van der Kolk, 2001, 2006). Perry and Pollard (1998) claimed that more than 8 million children suffer from a trauma-related neuropsychiatric disorder at any given moment. This chapter addresses child sexual abuse as one of a number of adverse events included in the evolving neurobiological view of complex childhood maltreatment (van der Kolk, 2001). Further, due to the negative impact of child maltreatment on specific low brain structures and the historical neglect of remediation for such trauma, treatment discussions focus on child maltreatment from a neurobiological perspective. Although the neurobiological view of trauma offers enormous advances in treatment design it does require a fundamental familiarity with a few basic brain development principles.

HUMAN BRAIN DEVELOPMENT

The human brain is a surprisingly dynamic structure, mediating not only life-support functions, but also those functions that make us most human (Lehrer, 2009). Unlike our heart, lungs, or most other organs, the brain constructs itself through an extraordinary interaction of genetics and experience. All we are and all we will become—our hopes, our dreams, our knowledge, our relationships and our emotional health—depend on the successful development of the brain. As human beings we are not fast, large, strong, nor do we have sharp teeth or claws compared to many other creatures of the earth. Instead, our survival is largely contingent on the unique properties of our brain. Unlike any other species on the earth, we sense, perceive, process, store, and act on information from both external and internal environment in evolutionarily profound ways. To accomplish this feat, the brain has evolved an efficient, predictable, and hierarchical process of development and organization. Understanding this organization and essential brain processes holds valuable keys to successful treatment of maltreated children.

The human brain develops and organizes in a systematic and hierarchical fashion beginning very early in utero. First driven by genetics and later by experience, the brain is constructed through the interplay between nature and nurture. Because of this interaction between nature and nurture, the brain will become uniquely designed to support the survival of the young child in the world he or she experiences. This organizational process was first conceptualized as being from the bottom up in the early nineteenth century (Jackson, 1958). Maturation and development of the human brain recapitulates evolution, with brainstem and diencephalon regions developing first (Lehrer, 2009). These lower brain regions organize and develop early in utero and will continue in a systematic and predictable fashion, being functional before preschool. As is the case with most developmental processes, those organs or systems that will be required for survival develop first.

Lower brain regions, brainstem and diencephalon, develop early as they control basic life-support functions such as respiration, heart rate, blood pressure, and other critical activities. Higher brain regions develop later and more slowly than the lower brain areas as they are less critical to survival immediately after birth. The higher brain regions of the limbic and cortex areas mediate intricate functions of thinking and emotional regulation. As each of these areas develop and mature they become more sophisticated and efficient in function. The child will progressively display each new skill, called *developmental milestones,* as the various parts of the brain mature, becoming fully functional by puberty (Lehrer, 2009). The various brain regions connect within each region and between regions to form a massive neural network making the transfer of information possible (Perry, 2006). This information can then be perceived, processed, and integrated into various other parts of the brain, creating a huge array of brain functions greatly enhancing our ability to survive through successful

management of our relationships and environment (MacLean, 1990; Perry, 2006; van der Kolk, 2006).

ORDER OF PROCESSING

The traditional view of the brain has been one of sequentially processing incoming sensory information beginning at the brainstem (bottom) through the diencephalon, limbic system, and finally the cortex (Jackson, 1958; MacLean, 1990). This model of neural processing implies that the ultimate capacity of integration and processing resides with the cortex, giving the human the capability to manage or cope with the environment. Jackson (1958) believed that the higher brain functions were able to inhibit and control the lower more primitive brain regions. In this dated view, the cortex logically analyzed incoming information and made rational decisions about responses, which were then put into action. The lower brain regions took over only when the higher regions were rendered functionless. This view attributed absolute executive control of the brain to the cortex (Lehrer, 2009). The belief in the superiority of reason to quell emotional impulses dates back to Plato, Descartes, and even Freud (Lehrer, 2009). For most of the twentieth century this notion has prevailed philosophically and is a central tenet in most therapeutic approaches. In fact, under normal conditions the executive and symbolizing capacities of the prefrontal cortex are capable of modifying the more primitive, lower brain region's impulses by inhibiting, organizing, and modulating those autonomic responses (Lehrer, 2009; van der Kolk, 2006). However, research has now demonstrated that it is only partially true and under certain conditions totally erroneous (Perry, 2006, 2008; Perry & Pollard, 1998; van der Kolk, 2006). It is now known that the lower brain regions (brainstem and diencephalon) are capable of functional changes in autonomic excitability and numerous homeostatic states in response to environmental influences without and independent of cortex involvement (Lehrer, 2010; Miller, 1969).

MULTILEVEL RESPONDING

To appreciate the significance of the multilevel responding capacity in the brain, it is instructive to trace neural pathways from the brainstem to the cortex. Perry and Pollard (1998) described the course of sensory input from both the internal environment (blood glucose, arterial pressure, CO_2 levels) and external environment (visual, auditory, tactile, olfactory, and gustatory) as generally traveling first from the peripheral nervous system (PNS) to the spinal cord. Once the impulse reached the spinal cord, sensory information initially entered the brain at the lower, regulatory, and motor areas of the brainstem and into the diencephalon. Neural activity entered the low brain regions as separate, preconscious impulses; unavailable to conscious awareness or verbalization. Even at this level, sorting, integrating, interpreting, storing, and responding began. As the primary sensory signals were processed and reprocessed through sensory association centers, co-occurring signals become connected (Perry, 2006). It is now known that most sensory processing occurs outside of conscious awareness. Only novel, significant, or threatening information is passed onto higher brain levels for further attention (van der Kolk, 1994).

Contrary to cortex superiority models, each brain level interprets stimuli matching it to stored, previous patterns of activation, and initiates a response. As the neural activity is transmitted to higher, more complex areas (limbic and cortical), more intricate cognitive associations are made, allowing interpretation of the experience. The patterns of neural activity are again matched against previously stored patterns of activation and placed in conscious memory (Perry, 2006; van der Kolk, 2006). The neural event can now be categorized, contextualized, understood, stored, and recalled consciously within a larger perceptual or cognitive framework (Perry, 2006; van der Kolk, 2006). This is a truly remarkable mental ability of the human brain. It is at this level of processing that neuronal activity first results in conscious emotional sensations (Perry, 2008; Perry & Pollard 1998; van der Kolk, 2006).

THREAT ASSOCIATIONS

As these sensory stimuli are matched and sorted, signals that are associated with previously identified threat or unknown potential threat trigger an initial alarm response at the most primitive levels of the brain. This alarm response activates neuronal activity in key brainstem and diencephalon nuclei, which contain neurotransmitters (Perry, 2006; van der Kolk, 2006). The fact that sensory input can automatically stimulate hormonal secretions and influence the activation of brain regions involved in attention and memory points to the limitations of conscious control over our actions and emotions. This is particularly relevant in understanding and treating traumatized individuals. It explains why trauma survivors are prone to display irrational, subcortically initiated responses that might be irrelevant, unproductive, or even harmful in the current context (van der Kolk, 2006).

This initial threat response initiates brainstem and midbrain activity, triggering immediate responses to the perceived threat, in near reflexive or Pavlovian fashion (van der Kolk, 1994). Responses at this level of brain function occur long before the signals reach higher cortical areas to be

interpreted and ultimately acted on. This process has remarkable survival value as the low brain is making critical decisions for safety and survival when waiting for more detailed and analytical decisions would be detrimental (Lehrer, 2009; Perry, 2006, 2008; van der Kolk, 2006). Obviously, such immediate responses suggest that the lower brain regions are able to compare old patterns associated with threat to patterns just perceived. Perry (2006) calls these associations state memory. This nonverbal, illogical, unconscious association resulting in alarm activation occurs before complete processing and interpretation is completed by the cortex (Perry, 2006). It should also be noted that the cortex is easily overwhelmed. Under stress, the lower brain regions simply take over and shut down higher cortical regions. The cortex is in many ways a puny organ (Lehrer, 2009; van der Kolk, 2006).

Van der Kolk (2006) states that the rational brain (cortex), while able to organize feelings and impulses, does not seem to be particularly well equipped to abolish emotions, thoughts, and impulses. Neural imaging of humans in highly emotional states reveals that intense emotions of fear, sadness, anger, and happiness cause increased activation of sub cortical brain regions and significant reduction in blood flow in various areas in the frontal lobe (van der Kolk 2006). Van der Kolk (1994) also points out that traumatic experiences activate brain regions that trigger intense emotions and decrease activation of the central nervous system (CNS) regions involved in integration of sensory input, motor output, attention, memory, memory consolidation, modulation of physiological arousal, and the ability to communicate with words. Sympathetic nervous system arousal is greatly mobilized preparing the body for a physical fight or flight response. Nearly two-thirds of traumatized children show such symptoms resulting from increased adrenergic activity (van der Kolk, 2006). Physiological responses commonly involved include: stimulated sweat glands, inhibition of gastrointestinal processes, increased cardiac activity, increased blood pressure, increased respiration, anxiety, or hypervigilance (Hopper, Spinazzola, Simpson, & van der Kolk, 2006). Finally, such intense responses to stressful experiences decrease the child's ability to organize a modulated behavioral reaction and to be engaged in the present (Hooper et al., 2006; Perry, 2008; van der Kolk, 2006).

Perry (2008) pointed out, from a neurobiological point of view, excessive or protracted traumatic experiences unmistakably cause profound alterations in the regulation and functioning of many bodily systems. This in turn can result in new dysfunctional brain patterns influencing the organization and function of higher brain areas. This results in compromised function and ultimately psychopathology. Experience, positive or negative, becomes the neural architecture of the child's brain (Perry, 2008).

STATES BECOME TRAITS

Finally, as has been previously alluded to, brain development is profoundly guided by experience. The sequential nature of neural development and brain function is heavily directed by and modified by the child's interaction with the environment. In a positive sense, the ability to create an internal representation of the external world or internal world through repeated activation is a useful memory and learning tool (Perry & Hambrick, 2008). This means that the greater the frequency of activation of a neural system, the more permanent the neural state becomes. Perry and Hambrick (2008) described neurons and neuronal networks as literally being modified through repeated experiences in what they called an activity or use-dependent process.

Just as the use-dependent process can create positive learning and memory, so can it create negative learning and memory due to neglect, trauma, or chaos. The precortical associations in the case of trauma or neglect are between sensory cues and the autonomic responses of threat. These subcortical signals are capable of eliciting a fear response, altering emotions, behaviors, and physiology. In the case of neglect, the neural system gets so little stimulation that neural systems fail to form and neurons atrophy and disappear. Sadly, these changes can become permanent (Perry, 2006).

Physiological arousal in general triggers trauma related memories, while conversely, trauma related memories precipitate generalized physiological arousal. Studies have demonstrated how the response to potent environmental stimuli (unconditional stimuli) becomes a conditioned reaction. After repeated aversive stimulation, intrinsically nonthreatening cues associated with the trauma (conditional stimuli) become capable of eliciting the defensive reaction by themselves (conditioned response) in a classical Pavlovian fashion (van der Kolk, 1994). The eliciting cue can be any sensory experience that becomes associated with the trauma. It could be eye contact, a smile, a smell, or a gesture (Perry, 2006; van der Kolk, 2006). Much of the resulting dysfunctional relational interaction will be beyond the awareness and understanding of the developing child or youth (Perry, 2006). If the traumatic experiences create a use-dependent state powerful enough, profound regressive changes will be noted in the child's thinking, behavior, and perceptions. Perry and Pollard (1998) described these changes as primitive brainstem driven behavior.

Trauma induces a total brain response. All parts of the brain will be affected by the survival reaction. Cortex, limbic, diencephalon, and brainstem will all create altered memories based on the traumatic experience.

The brain's prior homeostatic state memories will be changed cognitively, emotionally, motorically, and physiologically (Perry & Pollard, 1998). Children experiencing such alterations often express these alterations through academic problems, emotional or relational problems, sensory-motor problems, or core physiological problems. These difficulties will also result in the child having great difficulty benefiting from therapies using cognitive methods, language, or therapeutic relationships as remedial interventions (Perry, 2006; van der Kolk, 2006).

INCREASED VULNERABILITY OF CHILDHOOD

The brain's response to threat is well documented, but the incomplete neural developmental architecture of the child's brain presents additional concerns for treatment of traumatized children (Perry & Pollard, 1998; van der Kolk, 2006). Perry and Pollard (1998) pointed out that adults sometimes believe and speak of children as being resilient to traumatic events because of their young age. In these cases, adults perceive children as possessing qualities that insulate or protect them from the disorganizing impact of psychosocial maltreatment. To the contrary, nearly 20 years of research in child maltreatment has made it abundantly clear that this is not the case. In fact, children are much more vulnerable to trauma during early development than during later development (Perry & Pollard, 1998).

An uncomfortable reality of sequential brain development is that the organizing, sensitive brain of an infant or young child is more malleable to experience than the mature brain. Although traumatic experience may negatively affect the function of an adult, this same experience literally becomes the neural organization for an infant or child's brain (Perry, 2006). This explains why the beneficial effect of psychotherapy was primarily found in adult-onset trauma survivors. Seventy-five percent of the adults achieved asymptomatic ratings while only 33.3% of the child onset survivors achieved asymptomatic status (van der Kolk et al., 2007). This is not surprising given the child's immature neural developmental status versus the adults more mature neurological state. The result of child-onset trauma is that the brain becomes poorly developed and functionally disorganized, rendering the child less able to intellectually, verbally, or emotionally respond to normal experiences let alone traumatic ones. Perry and Pollard (1998) continued by pointing out that although the young child will be unable to effectively respond to the trauma, the child is still capable of experiencing a fear-induced startle response, emotional distress, or any age-appropriate reactivity in response to a traumatic experience. What the child cannot do is understand, symbolize, or verbalize the experience to others. Sometimes adults mistakenly view the lack of a response as emotional resilience. When children suffer such disorganizing neurobiological trauma, therapeutic change must be in the form of repeated opportunities for new experiences which allow the brain to either break false associations or decrease the overgeneralization of trauma-related associations (Perry, 2006).

For millions of abused and neglected children, their maladaptive and traumatic experiences have profoundly altered their brain development (for review, see Perry, 2008). The traumatic experiences have created a new, but less functional, less flexible state of equilibrium (Perry & Pollard, 1998). Children living in chaos, neglect, abuse, or threat do not have the opportunity to develop the fundamental experiences required to express their full potential for self-regulation, relationships, communication, or thinking. They become poorly socialized and at risk for profound and lasting emotional, behavioral, social, cognitive, and physical health problems (Anda et al., 2006; Perry, 2006; Perry et al., 1995; Perry & Pollard, 1998).

Trauma symptoms common to traumatized children generally feature intrusive recollections; persistent avoidance of associated stimuli or numbing of general responsiveness; and arousal symptoms of hyperarousal, hypervigilance, startle response, sleep difficulties, irritability, anxiety, and physiological hyperactivity. With repeated activation the symptoms will begin to generalize to other stimuli resembling the traumatic memory, eliciting complex, multisystem symptomatology (Perry, Conroy, & Ravitz, 1991). Other symptoms routinely associated with traumatized children are behavioral impulsivity, increased muscle tone, anxiety, a focus on threat-related cues (often no-verbal), affect regulation, language problems, fine and gross motor delays, disorganized attachment, dysphoria, attention difficulties, memory problems, and hyperactivity (Perry et al., 1995). In addition, interfamilial abuse has been increasingly documented as contributory to complex trauma involving chronic affect disregulation, and destructive behavior against self and others, learning disabilities, dissociative problems, somatization, and distortions in concepts about self and others (Hooper et al., 2007; van der Kolk, 1994; van der Kolk, 2001). Studies of global neglect have further contributed to the appalling picture of maltreatment identifying abnormalities in brain size, enlarged ventricles, cortical atrophy, alteration in the corpus callosum, decreased metabolic activity in the orbital frontal gyrus, infralimbic prefrontal cortex, amygdala and head of the hippocampus, lateral temporal cortex, as well as the brainstem (Perry, 2005, 2008).Treatment approaches need to be examined and reexamined in light of the growing knowledge of how the brain learns and how it is affected by environmental influences.

BARRIERS TO INTEGRATION OF NEUROBIOLOGICAL INFORMATION

Many well-intended intervention efforts have been misinformed about the fundamental principles of brain organization, development, and functioning, and were predestined to fail (Perry, 2006; 2009; Perry & Hambrick, 2008; van der Kolk, 2004, 2006). Both Perry and van der Kolk clearly contend that treatment designs lacking basic neurobiological principles regarding how the brain develops and changes cannot expect to be effective. This problem has been characteristically evident in treatment of maltreated children (Perry & Hambrick, 2008).

Many approaches ignore a significant noncortical, illogical, nonverbal, sensory-motor-oriented component of social and emotional trauma, frequently resulting in chronic, resistant, and persistent symptomatology (Perry, 2006; Perry & Pollard, 1998; Perry & Szalavitz, 2006; van der Kolk, 2006). Even recent noteworthy discussions of preverbal trauma (Green, Crenshaw, & Kolos, 2010) consider only the limbic and cortical brain, not autonomic level trauma. The history of neglecting low brain contributions to trauma symptomatology has been the result of early therapists being unaware of the principles of neurodevelopment and neurotraumatology (van der Kolk, 2006).

A second limiting factor has been the limited availability of therapeutic services that provide sufficient repetition to reorganize long-standing disorganized low brain systems (Perry, 2006). *When years of chaos, trauma, or neglect have robbed a child of essential organizing experiences, the number of therapeutically necessary repetitions required to stimulate the growth and development of missing or deficient abilities (neural organization of the brain) will be high and require a protracted effort*. This has been discouraging to adults and professionals who expected much quicker results to their nurturing and supportive interventions. Professionals, caregivers, and parents must come to realize that the frequency of remedial repetitions required to modify low brain dysfunctional patterns will be very high. Certainly it will be higher than required to organize higher level brain regions (Perry, 2006). Clearly, traditional therapeutic thinking has not always taken into account how difficult it is to transform dysfunctional neural systems fashioned over years. Therapies and therapists by themselves have been able to provide but a small fraction of the reorganizing contribution required for healing global trauma. Maltreated children frequently need intensified regularity and quality of relational interactions. The standard weekly therapy session is not sufficient to development healthy functioning after years of chaos and dysfunctional living. The greater the degree of disorganization noted in the child the more critical the need for massive quantities of healthy interactions. This may well require therapeutic environments that have an adult to child social ratios as low as 1:1, even for children much older than those normally receiving this much attention (Perry, 2006). In many cases, the required number of healthy interactions essential to transform ingrained low brain neural patterns will be so high that many caretakers (parents, teachers, family, etc.) must be actively committed to participating in the effort (Perry & Hambrick, 2008).

Third, traditional therapies have paid limited attention to posttraumatic changes in body experience or what van der Kolk called the sensate dimensions of life (van der Kolk, 2004, 2006). Neuroscience has demonstrated that emotional states arise from conditions experienced within our bodies, such as hormones, internal organs, or muscles tension (van der Kolk, 1994). Therapies have customarily promoted understanding, acceptance, emotional processing, insight, and problem-solving regarding what happened in the patient's life to create such powerful reactions (van der Kolk, 2004). Contrary to this historical treatment perspective, brain science now informs us that the dorsolateral prefrontal cortex which is involved with insight, understanding, and planning for the future, has virtually no connecting pathways to the lower level brain centers that generate and elaborate these powerful trauma reactions (van der Kolk, 2004, 2006). Consequently, common therapies that are psychodynamic or cognitive behavioral in orientation may pay insufficient attention to disturbed autonomic physical sensations and preprogrammed physical action patterns (van der Kolk, 2006). Perry (2006) continued with this line of thought when he stated that talk therapies and therapeutically relational interactions have not proven effective in changing low brain (brainstem or diencephalon) experience. Again the best cognitive-behavioral or insight-oriented or even affect-based therapies fail if the brainstem is poorly regulated. The child's excessive anxiety, hypervigilance, and habitually activated threat response undermine academic, therapeutic, and social-emotional interventions (Perry, 2006).

NEUROBIOLOGICALLY BASED TREATMENT

Perry (2006), van der Kolk (2006), Cook et al. (2005), and others have made it evident that insight, understanding, integration, acceptance, emotional processing, and problem-solving therapy strategies offer limited assistance to children suffering from common autonomically mediated symptoms such as fear and anxiety states of hyperarousal, hypervigilance, sleep

disturbances, as well as physiological reactions of increased heart rate, blood pressure, and respiration (Perry & Hambrick, 2008).

Although treatment for neglect and abuse will ultimately need to focus on higher cognitive issues, the more cortically mediated problems should be addressed later after fundamental low brain regulation is established (Cook et al., 2005). Until state regulation or healthy homeostasis is established at the brainstem level, higher brain mediated treatments will be less effective (Perry & Hambrick, 2008). With young maltreated children, this may mean developing healthy state regulation for the first time in their lives. Using the bottom up analogy of brain processing, establishing a sense of safety and self-regulation (lower brain mediated) must supersede insightful reflection, trauma experience integration, relational engagement, or positive affect enhancement as these last elements of treatment are mediated through cortical and limbic areas (Cook et al., 2005). This new conceptual view of trauma treatment requires us to search for therapeutic methods that offer hope for reprogramming autonomic primitive, low brain dysfunctional or disorganized learning. The solution rests with the notion that if adverse experiences altered the developing brain in negative ways, then healthy therapeutic experiences can change the brain in ways that promote healing, recovery, and restoration of healthy functioning (Perry, 2006).

NEUROBIOLOGICALLY INFORMED INTERVENTION

The challenge of finding helpful interventions for low brain dysfunction may begin by looking into the past. Just as useful medical treatments have been derived from ancient remedies, valuable mental health treatments can also be derived from our ancestral emotional healing practices. Throughout our existence on earth, human beings have calmed each other when overwhelmed, distraught, or distressed through sensory experiences such as touch, through patterned, repetitive movements of dance, holding, rocking; and through rhythmic use of music, drumming, song, or chanting. Neurologically, each of these interventions has their origin in low brain regions rendering them nonverbal, sensorial, and movement oriented. Such methods have been used as healing rituals for thousands of years as part of intensely relational experiences with family, loved ones, and friends being an integral part of the process (Perry, 2009; van der Kolk, 2001). The quest for methods to return traumatized children to a state of quiescence or to create such a state requires a willingness to look back at our neurobiological origin, our developmental history, and our ancestral remedial practices.

To date, the few treatment designs that have utilized developmentally appropriate interventions which emulate normal development have been encouraging (Perry, 2006; Perry, 2009; Perry & Hambrick, 2008; van der Kolk, 2006) In fact, such protocols have been demonstrated to be more effective than traditional talk therapy or pharmacological approaches in achieving reductions in core trauma symptoms, and promoting healthy social emotional development (Miranda, Arthur, Mahoney, & Perry, 1998; Miranda, Schilick, Dobson, Hogan, & Perry, 1999; van der Kolk, 2001, 2007; Barfield et al., in preparation). These early treatment designs demonstrate that the specific nature, pattern, timing, and duration of remedial experiences are crucial to successful therapeutic reorganization of low brain functions. Developmentally appropriate intervention means the remedial activity must match the natural or biological organizing processes of the brain region affected. The pattern and timing of the corrective activity must also match the normal process of that brain region. So, if a brain region is typically organized by specific rhythmic, sequential patterns that normally occur with a caregiver at heart rate (e.g., rocking the child at about 60 beats per minute), the same pattern needs to be replicated in the treatment design through some experiential modality (a rocking chair or swinging at the same rate). Finally, the duration of the activity also needs to approximate the normal developmental course. That is, treatment actions that are primarily sensory or motor in nature must be longer in duration, with frequent repetitions, and with a greater relational concentration than is normally common in traditional therapy designs.

Perry (2006) characterized successful neurobiologically informed treatment as pairing the right therapeutic activity from a specific developmental stage with the physiological needs of a maltreated child. The critical concept therapeutically is that brain regions not activated do not change (Perry, 2006). This inadequate appreciation of neurological change agents has greatly influenced the movement toward pharmacology treatment for low brain symptoms of trauma. The shortcoming of pharmacological intervention is that such treatments fail to create new learning, fail to create natural neurologically patterned calm homeostatic states, or in other words self-regulation. This learning can only be accomplished by repeated, patterned experiences, using the sensory modalities specific to the brain region to be affected.

Nontraditional treatments for hyperarousal and associated symptoms resulting from early histories of chaos; physical, emotional, or sexual abuse; neglect; or violence have not enjoyed widespread use in Western culture (van der Kolk, 2006). Nonetheless, most adults and children with trauma-related problems need some form of body-oriented therapy to regain a sense of control or self-regulation over their bodies, or in the case of early maltreatment, to establish healthy patterns for the first time (Cook et al., 2005; van der Kolk, 2009). Fortunately, there have been some notable

attempts to develop specific body-oriented treatment techniques and psychodramatic techniques focusing on experiencing, tolerating, and transforming trauma-related sensations (van der Kolk, 2001). Among these techniques, Eye Movement Desensitization and Reprocessing (EMDR), focusing, sensory awareness, Feldenkrais, rolfing, FM Alexander technique, body-mind centering, somatic experiencing, Pesso-Boyden psychotherapy, Rubenfeld synergy, and Hakomi have all been used successfully, at least with adults (van der Kolk, 2001, 2006).

Although there may be useful applications of these adult techniques for children, remediation for low brain disorganization for children realistically relies heavily on play and play activities that emulate normal healthy behavior, developmentally matched to the brain region targeted for change. Play is a primal, complex process that occurs spontaneously when children are given the freedom to follow their innate nature (Brown, 2009). Play is naturally pleasurable and generally thought to be the organizing activity that shapes the child's physical, social, emotional, and cognitive perceptual view of the world (Brown, 2009; Louv, 2008). Play is the intrinsic, neurological process intended to program the child's brain. These properties make play an excellent process to reorganized brain systems that have been negatively affected by maltreatment. However, it is vitally important that the therapist understand that at the brainstem and diencephalon level play are a primary process that is nonverbal. These low brain regions do not comprehend nor respond to spoken language. They both respond to the "language" of the senses and movement. As such, they are very sensory, primarily visual and tactile, but auditory perception of tone, rhythm, and pitch have an influence as well (Schore, 1994). Primary process communication relies on eye contact, face-to-face gaze, facial gestures, touch, physical movement, and rhythm. These communication mediums are central to low brain remedial efforts as they are the modalities recognized by the low brain. As primary process communication begins, the adult must establish an attuned state with the child. That is, the two are in a harmonic emotional state that actually synchronizes their neural activity, heart rates, and hormonal systems all of which are critical to later self-regulation (Stern, 1985). The adult must maintain themselves in a calm state and be the safe island for the child. The intent of this type of interaction is that the child will synchronize with the adult. In this process the child's arousal level is brought under regulatory control by matching the adult's calmer arousal level. Sensory regulation of the child mediated by the adult must come before self-regulation mediated by the child (Perry, personal communication, 11–14–08). Limiting stimuli (light, sound, movement, and people) to decrease arousal and sooth the child are critical to creating a state of regulation.

Brainstem regulation of the child is done almost exclusively through soothing, calming, pacifying sensory activity. The attuned caregiver rapidly begins to discover the child's favored sensory systems and which activities present the sensory stimulation in ways the child finds soothing and quieting. These activities may include elements of gentle touch, massage, hugs, cuddling, skin-to-skin contact, music, rocking, swinging, grooming, breathing exercises, sucking, chewing, warm baths, lullabies, songs, music, textures of all kinds to feel, pudding painting, finger painting, playing with clay, sand or mud, and so on. The list is limited only by one's imagination, but the activity must be experienced by the child as pleasurable and must be carried out in an intensely relational context. The same activity devoid of positive relational qualities will fail to produce the desired neurological change. It must be remembered that this process is not a cookbook of activities; to the contrary it is a richly relational and neurobiological process, entered into by a child and an adult who want to be emotionally connected at a particular moment in time.

Diencephalon activities, which often are comingled with the brainstem activities under the rubric of low brain remediation, consist normally of rhythmic, sequenced motor or exercise activities for both fine and gross motor play, as well as continued sensory play. Specific activities offering regulation for this brain region may include: rocking, swinging, crawling through tubes, blanket mazes, or boxes, piggy back rides, rocking boats, playground equipment, play with balls, hoops, or bean bags, jumping ball, rocking horses, hula hoops, throwing, catching, kicking, swimming, hand-clapping games, jumping rope, ball bouncing games, hop scotch, tricycles, scooter boards, bikes, walking through mazes or labyrinths, hatha yoga, yoga, tai chi, reiki touch, pressure points, dance, and so on. Again it is not the activity alone that produces the positive change, but done in conjunction with an intensely positive relational climate.

The search for activities that can be expected to stimulate the low brain centers often leads to consideration of non-Western healing traditions. Fortunately such traditions offer some insights regarding physical movement and breathing through the use of yoga, qigong, and tai chi to regulate emotional and physiological states. These activities may be too advanced for small children, but they are practical for grade school and older children and might be used to augment the exercises mentioned earlier. Yoga and other closely related modalities have been used successfully to regulate core arousal systems in the brain and promote comfort with one's own body. It is a useful method to attain a sense of comfort with one's physical sensations and to develop a sense of inner quietness. In this sense, yoga is believed to calm core regulatory mechanisms in the lower brain regions (van der Kolk, 2009). In fact, some studies found yoga

superior to Dialectic Behavioral Training (DBT) in decreasing the frequency of intrusions and severity of hyperarousal symptoms (van der Kolk, 2006). Also, hatha yoga has successfully lowered heart rate and improved muscular and vascular concomitants of posttraumatic stress disorder (PTSD) clients. The gains in low brain self-regulation seemed the result of increased awareness of sensory stimuli during formal practice (van der Kolk, 2006). According to van der Kolk (2001), meditation practitioners became progressively more adept at managing stressful reactions. Yoga seemed to help them feel comfortable with their physical sensations and to develop an inner quietness or stillness. Van der Kolk (2001) also reported mindfulness as a fundamental skill that created a sense of mastery over physiological arousal. This mindful or meditative quality promoted the ability to discern between internal sensations and the external events that precipitated them. The goal of therapy, van der Kolk proposed, was to create the capacity to be mindful of current experience and to create symbolic representations of the past traumatic experience with the aim of uncoupling physical sensation from trauma based emotional responses. The uncoupling was accomplished by decreasing the intensity and duration of hyperarousal states.

NEUROSEQUENTIAL MODEL OF THERAPEUTICS

One of the first neurobiological treatment models of child maltreatment was developed by the Child Trauma Academy. This model uses traditional and nontraditional therapy activities directed by core principles of neuroscience (Perry, 2006; Perry & Hambrick, 2008). The Neurosequential Model of Therapeutics (NMT) is not specifically a treatment technique, but rather a developmentally sensitive and neurobiologically informed method of conceptualizing child trauma and designing interventions (Perry, 2006, 2009). The NMT stresses the importance of prescribing remedial interventions that match the child's functional developmental stage (not necessarily the chronological stage) and the brain region mediating the neuropsychiatric condition (Perry & Hambrick, 2008). The three primary objectives are to first assess specific problems and the mediating disorganized brain region; second, identify key strengths that will enhance remediation; and third, determine specific interventions that will meet the needs of the child (Perry, 2006, 2009).

Successful treatment is dependent on applying several core principles of brain development. First is the importance of restoration of the perception of safety and control in the traumatized child (Perry, 2006). Children do not make progress clinically when they are frightened or feel out of control (Walsh, Blaustein, Knight, Spinazzola, & van der Kolk, 2007). Remember, even with excellent child protective services, investigation, placement, and litigation can easily contribute to the child's fearful out of control experiences. Therapists must work to help the child regain some sense of consistency, routine, familiarity, and control in their lives. Only then will treatment interventions have maximal impact. Human beings do not make developmental progress when under threat (Perry, 2006).

Second, treatment services will be most effective when they mirror children's normal developmental path. An assessment of the neurobiological history is conducted to determine the most appropriate sequencing of services (Perry & Hambrick, 2008). Third, therapeutic services must be consistent, predictable, patterned, and highly repetitive. For such interventions to be successful in reorganizing destructive low brain memory templates, the number of repetitions of positive organizing experiences must be very high. This may require repetitions multiple times a week or even daily. Unfortunately, this is often beyond the capability of traditional weekly therapy sessions. Pragmatically, therapeutic services must be carried out in multiple spheres of the child's life. Only by using parents, caregivers, teachers, and others can the requisite number of repetitions be attainable of constructive change (Perry, 2006). Fourth, since multiple deficits often coexist, they must be addressed in a specific order. The concept is a simple one, treatment must follow the natural hierarchy of brain development, beginning at the lowest level of brain disorganization or pathologically functioning. Commonly, the more closely restorative efforts mimic the normal sequence and process of development the greater the effectiveness (Perry, 2006). As mastery is attained, treatment begins to slowly resemble the next developmental stage. Treatment customarily begins at the lowest disorganized brain region (Perry, 2006).

CONCLUSION

The neurobiological perspective offers revolutionary explanatory power regarding the origin and development of trauma related symptoms and their resistance to treatment. The neurobiological perspective also offers a means to understand traumatic hyperarousal, flashbacks, and retriggering as autonomically mediated low brain activity. Further, it offers an unparalleled conceptual framework for designing interventions for maltreated children, with low brain dysfunction (Perry, 2008; van der Kolk, 2001). To fully utilize the neurological impact of psychosocial trauma on the developing brain of a child and to effectively treat the resulting developmentally specific trauma, the helping professionals involved with children should apply basic principles of brain function and development to intervention for children suffering from complex trauma.

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