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Examining Child Maltreatment Through a Neurodevelopmental Lens: Clinical Applications of the Neurosequential Model of Therapeutics

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This article provides the theoretical rationale and overview of a neurodevelopmentally-informed approach to therapeutic work with maltreated and traumatized children and youth. Rather than focusing on any specific therapeutic technique, the Neurosequential Model of Therapeutics (NMT) allows identification of the key systems and areas in the brain which have been impacted by adverse developmental experiences and helps target the selection and sequence of therapeutic, enrichment, and educational activities. In the preliminary applications of this approach in a variety of clinical settings, the outcomes have been positive. More in depth evaluation of this approach is warranted, and is underway.

Over the last 30 years, key findings in developmental neurobiology have informed and influenced practice in several clinical disciplines, including pediatrics, psychology, social work, and psychiatry. Despite this influence, the capacity of these large clinical fields to incorporate and translate key neurobiological principles into practice, program, and policy has been inefficient and inconsistent. The purpose of this article is to present preliminary efforts to integrate core concepts of neurodevelopment into a practical clinical approach with maltreated children. This neurosequential model of therapeutics (NMT) has been utilized in a variety of clinical settings such as therapeutic preschools, outpatient mental health clinics, and residential treatment centers with promising results (Perry, 2006; Barfield et al., 2009).

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CONTEXT AND CURRENT STATUS

Development is a complex and dynamic process involving billions of interactions across multiple micro (e.g., the synapse) and macro domains (e.g., maternal-child interactions). These interactions result in a unique expression of an individual's genetic potential and create a miracle of dynamic organization in the trillions of component parts (e.g., neurons, glia, synapses) comprising the human brain. Maltreatment disrupts this hardy process; trauma, neglect, and related experiences of maltreatment such as prenatal exposure to drugs or alcohol and impaired early bonding all influence the developing brain. These adverse experiences interfere with normal patterns of experience-guided neurodevelopment by creating extreme and abnormal patterns of neural and neurohormonal activity. The resulting negative functional impact of impaired or abusive caregiving on the developing child has been well documented (e.g., Malinosky-Rummell & Hansen, 1993; Margolin & Gordis, 2000). As expected, in any brain-mediated function examined—from speech to motor functioning to social, emotional, or behavioral regulation—developmental trauma and maltreatment increase risk of dysfunction (see also Perry & Pollard, 1998; Bremner & Vermetten, 2001; Perry, 2001, 2002; Anda et al., 2006).

In the United States alone, there are millions of maltreated children and youth in the educational, mental health, child protective, and juvenile justice systems (Fitzpatrick & Boldizar, 1993; Graham-Berman & Levendosky, 1998). The majority of these children do not receive adequate mental health services; indeed, most are not even known to be maltreated or traumatized. While current policy efforts to create trauma-informed practices and programs are a welcome start, for children and youth, focusing on trauma alone is insufficient. Practice, program, and policy must become substance abuse, attachment, and neglect informed as well; we must become fully "developmentally informed" to understand and address the range of problems related to maltreatment. The following sampling of some principles of neurodevelopment illustrates the value of this broader view for clinical practice.

PRINCIPLES OF NEURODEVELOPMENT

There are many well-documented and emerging findings regarding the genetics, epigenetics, and experience-determined elements of neurodevelopment. Only a few are listed below to serve as examples of how these facts and concepts can inform our understanding of maltreated children and therapeutic work. More complete reviews are available elsewhere (e.g., Perry, 2001, 2002, 2006, 2008).

Sequential Development

The brain is organized in a hierarchical fashion with four main anatomically distinct regions: brainstem, diencephalon, limbic system, and cortex. During development the brain organizes itself from the bottom up, from the least (brainstem) to the most complex (limbic, cortical) areas. While significantly interconnected, each of these regions mediates distinct functions, with the lower, structurally simpler areas mediating basic regulatory functions and the highest, most complex structures (cortical) mediating the most complex functions. Each of these main regions develops, organizes, and becomes fully functional at different times during childhood. At birth, for example, the brainstem areas responsible for regulating cardiovascular and respiratory function must be intact for the infant to survive, and any malfunction is immediately observable. The neural networks involved, therefore, must be mostly organized in utero in order to become functional at birth. In contrast, the cortical areas responsible for abstract cognition have years before they will become fully organized and functional. Each brain area has its own timetable for development. Microneurodevelopmental processes such as synaptogenesis will be most active in different brain areas at different times and, thereby, be more sensitive to organizing or disruptive experiences during these times (sensitive periods).

As the brain is developing from the bottom to the top, the process is influenced by a host of neurotransmitter, neurohormone, and neuromodulator signals. These signals help target cells migrate, differentiate, sprout dendritic trees, and form synaptic connections. Some of the most important of these signals come from the monoamine neural systems (i.e., norepinephrine, dopamine, and serotonin). These crucial sets of widely distributed neural networks originate in the lower brain areas (brainstem and diencephalon) and project to every other part of the developing brain. This architecture allows these systems the unique capacity to communicate across multiple regions simultaneously and therefore provide an organizing and orchestrating role during development and later in life. Due to their wide distribution throughout the brain, and their role in mediating and modulating a huge array of functions, impairment in the organization and functioning of these monoamine neurotransmitter systems can result in a cascade of dysfunction from lower regions (where these system originate) up to all of the target areas higher in the brain. If the impairment occurs in utero (e.g., prenatal exposure to drugs or alcohol) or in early childhood (e.g., emotional neglect or trauma), this cascade of dysfunction can disrupt normal development. Simply put, the organization of higher parts of the brain depends upon input from the lower parts of the brain. If the patterns or incoming neural activity in these monoamine systems is regulated, synchronous, patterned, and of "normal" intensity, the higher areas will organize in healthier ways; if the patterns are extreme, dysregulated, and asynchronous, the higher areas will organize to reflect these abnormal patterns.

The clinical implications of this principle speak to the importance of the timing of developmental experience; the very same traumatic experience will impact an 18-month-old child differently than a 5-year-old. Similar traumatic experiences occurring at different times in the life of the same child will influence the brain in different ways; in many cases, the previous exposure has sensitized the child, making him or her more vulnerable to future events. And so it is with the timing of positive experience; the developmental stage of a child has a profound impact on how an educational, caregiving, or therapeutic experience will influence the brain; somatosensory nurturing, for example, will more quickly and efficiently shape the attachment neurobiology of the infant in comparison to the adolescent.

A more subtle clinical implication is that in order to most efficiently influence a higher function such as speech and language or socioemotional communication, the lower innervating neural networks (e.g., locus coeruleus norepinephrine systems) must be intact and well regulated. An overanxious, impulsive, dysregulated child will have a difficult time participating in, and benefiting from, services targeting social skills, self-esteem, and reading, for example. The field of restorative neurology has for many years emphasized the positive impact of repetitive motor activity in cognitive recovery from stroke. This principle suggests that therapeutic massage, yoga, balancing exercises, and music and movement, as well as similar somatosensory interventions that provide patterned, repetitive neural input to the brainstem and diencephalon monoamine neural networks, would be organizing and regulating input that would likely diminish anxiety, impulsivity, and other trauma-related symptoms that have their origins in dysregulation of these systems. Our preliminary findings, and those of others (B. van der Kolk, personal communication, June 2008) with maltreated children with such self-regulation problems, suggest that this is the case (Barfield et al., 2009).

Activity-Dependent Organization: Use-Dependent Modification

The brain organizes in a use-dependent fashion. In the developing brain, undifferentiated neural systems are critically dependent upon sets of environmental and micro-environmental cues (e.g., neurotransmitters, cellular adhesion molecules, neurohormones, amino acids, ions) in order for them to appropriately organize from their undifferentiated, immature forms (for reviews, see Perry, 2001, 2008). The molecular cues that guide development are dependent, in part, upon the experiences of the developing child. The quantity, pattern of activity, and nature of the activation from these neurochemical and neurotrophic factors depend upon the presence and the nature of the total sensory experience of the child. When the child has adverse experiences—loss, threat, neglect, and injury—there can be disruptions of neurodevelopment leading to compromised functioning (see below).

This principle has many clinical implications. Primary is the role this principle plays in psychopathology. Use-dependent changes in the brain are the origin of neuropsychiatric symptoms related to exposure to threat, fear, chaos, stress, and trauma. The monoamine systems mentioned earlier are crucial components of the stress-response neural networks in the brain.

When a child (or an adult) is threatened and activates this stress response in an extremely prolonged or repetitive fashion, the neural networks involved in this adaptive response will undergo a "use-dependent" alteration. The very molecular characteristics of individual neurons, synaptic distributions, dendritic trees, and a host of other microstructural and microchemical aspects of these important neural networks will change. And the end effect is an alteration in the baseline activity and reactivity of the stress response systems in the traumatized individual. The brain will "reset"—acting as if the individual is under persistent threat. The details of this process have been well described elsewhere (Perry & Pollard, 1998; Perry, 2001).

The principle of use dependence is at the heart of effective therapy. Therapy seeks to change the brain. Any efforts to change the brain or systems in the brain must provide experiences that can create patterned, repetitive activation in the neural systems that mediate the function/dysfunction that is the target of therapy. In many cases, this will mean (as mentioned above) that the target of the intervention should be the *innervating neural systems* and not the area or system that is the final mediator of the function/dysfunction (e.g., physical exercise helps stroke victims recover speech). This is a significant problem in the conventional mental health approach to maltreated children; many of their problems are related to disorganized or poorly regulated networks (e.g., the monoamines) originating lower in the brain. Yet, our clinical interventions often provide experiences that primarily target the *innervated* cortical or limbic (i.e., cognitive and relational interactions) regions in the brain and not the *innervating* source of the dysregulation (lower stress-response networks). Even when targeting the appropriate systems in the brain, we rarely provide the repetitions necessary to modify organized neural networks; 1 hour of therapy a week is insufficient to alter the accumulated impact of years of chaos, threat, loss, and humiliation. Inadequate "targeting" of our therapeutic activities to brain areas that are not the source of the symptoms and insufficient "repetitions" combine to make conventional mental health services for maltreated children ineffective.

The origins of—and therapeutic recovery from—neglect are manifestations of the principle of use dependence as well. Neglect, from a neurodevelopmental perspective, is the absence of the necessary timing, frequency, pattern, and nature of experience (and the patterns of neural activation caused by these experiences) required to express the genetic potential of a core capability (e.g., self-regulation, speech and language, capacity for healthy relational interactions). Neglect-related disruptions of experience-dependent neural signals during early life lead to a range of abnormalities or deficits in function (see Perry, 2001, 2006). As discussed above, the malleability of the brain shifts during development, and therefore the timing and specific "pattern" of neglect influence the final functional outcome. A child deprived of consistent, attentive, and attuned nurturing for the first 3 years of life who is then adopted and begins to receive attention, love, and nurturing may not be capable of benefiting from these experiences with the same malleability as an infant. In some cases, this later love is insufficient to overcome the dysfunctional organization of the neural systems mediating socioemotional interactions. With little appreciation of neurodevelopment, neglect-related problems in maltreated children are missed (in over 80% of children under the age of 6 removed by child protective services, there are significant developmental problems, yet this population rarely receives a developmental assessment in most states), ignored (a minority of children in child protective service care with mental health, learning, speech and language, or developmental problems receive consistent services), or lumped into the overinclusive current label of "complex" trauma or, worse, bipolar disorder. Even when children do receive mental health services, neglect-related issues are rarely appreciated as having a distinct pathophysiology and pathogenesis related to but different from trauma.

Disproportional Valence of Early Childhood Experience

The sequential development of the brain and the activity dependence of neurodevelopment create times during development when a given neural system is more sensitive to experience than others. In healthy development, that sensitivity allows the brain to rapidly and efficiently organize in response to the unique demands of a given environment to express from its broad genetic potential those characteristics that best fit the child's world; different genes can be expressed, and different neural networks can be organized from the child's potential to best fit that family, culture, and environment. We all are aware of how rapidly young children can learn language, develop new behaviors, and master new tasks. The very same neurodevelopmental sensitivity that allows amazing developmental advances in response to predictable, nurturing, repetitive, and enriching experiences makes the developing child vulnerable to adverse experiences.

The simple and unavoidable conclusion of these neurodevelopmental principles is that the organizing, sensitive brain of an infant or young child is more malleable to experience than a mature brain. While experience may alter the behavior of an adult, experience literally provides the organizing framework for an infant and child. Because the brain is most plastic (receptive to environmental input) in early childhood, the child is most vulnerable to variance of experience during this time. Again, the clinical, practice, and policy implications are profound. Early identification and aggressive early interventions are more effective than reactive services. Despite solid research documentation on early intervention and effective therapeutic services targeting young mothers, infant mental health, home visitation programs, and high-quality child care programs, support for these programs is scant and inadequate.

Relational Mediation of Major Developmental Experiences

Life is full of novelty, unpredictability, challenges, stressors, and, often, trauma. There are individual differences in how we cope with and overcome stress and trauma. Much is yet to be understood; genetic factors, for example, appear to influence hardiness or sensitivity. Yet, one recurring observation about resilience and coping with trauma is the power of healthy relationships to protect from and heal following stress, distress, and trauma. This relational modulation of stress is mediated by two interrelated and broadly distributed systems in the human brain: the stress response systems and neural networks involved in bonding, attachment, social communication, and affiliation. To best understand the intimate interdependence of these systems in the brain, it is useful to examine the conditions into which the human brain evolved.

For the vast majority of the last 200,000 years, humans have lived in hunter-gatherer clans in the natural world. The size of our living groups was small—40 to 60 people. These multigenerational, multifamily groups were the main source of safety from the dangers of the world. Our survival depended upon the ability to communicate, bond, share, and receive from other members of our family and clan. Without others, the individual could not survive in the natural world. Then, and today, the presence of familiar people projecting the social-emotional cues of acceptance, compassion, caring, and safety calms the stress response of the individual: "You are one of us, you are welcome, you are safe." This powerful positive effect of healthy relational interactions on the individual—mediated by the relational and stress-response neural systems—is at the core of relationally based protective mechanisms that help us survive and thrive following trauma and loss. Individuals who have few positive relational interactions (e.g., a child without a healthy family/clan) during or after trauma have a much more difficult time decreasing the trauma-induced activation of the stress response systems and therefore will be much more likely to have ongoing symptoms (i.e., there will be more prolonged and intense activation of the stress response systems and, hence, a "use-dependent" alteration in these systems). This capacity to benefit from relational interactions is, in turn, derived from our individual developmental experiences.

At birth, the developing stress-response networks in the brain (including the monoamine systems mentioned above) are rapidly organizing. The primary source of the patterned somatosensory interactions that provide the organizing neural input to the developing stress-response system is the primary caregiver. The role of the stress response system is to sense distress (e.g., hunger, thirst, cold, threat) and then act to address this challenge to homeostasis to promote survival: if hungry, eat; if cold, find shelter; if thirsty, drink. Infants are incapable of meeting their needs; they cannot feed, warm, or comfort themselves and depend upon their caregiver to become the external stress regulator. The primary caregiver, through consistent, nurturing, and predictable responsive caregiving, provides the patterned, repetitive neural stimulation (again, the principle of "use dependence") for the infant's developing brain required to build in an adaptive and flexible stress-response capacity (self-regulation) as well as healthy attachment capabilities. If the caregiver is depressed, stressed, high, inconsistent, or absent, these two crucial neural networks (stress-response and relational) develop abnormally. The result is a child more vulnerable to future stressors and less capable of benefiting from the healthy nurturing relational supports that might help buffer future stressors or trauma.

Early developmental experiences with caregivers—the infant's first exposure to humans—create a set of associations and "templates" for the child's brain about what humans are. Are humans safe, predictable? Are they a source of sustenance, comfort, and pleasure? Or are they unpredictable and a source of fear, chaos, pain, and loss? These initial caregiving experiences create the "template" that the child carries into future relational interactions, either increasing or decreasing the capacity of the child to benefit from future nurturing, caring, and invested adults. Relationships in early childhood, then, can alter the vulnerability/resilience balance for an individual child (do human relational interactions calm you when distressed because your "template" is based upon nurturing, or do they make you feel more anxious and vulnerable because your primary caregiver was inconsistent and abusive?).

There is another aspect of the interconnectedness of the stress response and relational neurobiology. The human experience is characterized by clan-on-clan, human-on-human competition for limited resources. Indeed, the major predator of humans is now, and has always been, other humans. In our competitive, violent past, encounters with unfamiliar, nonclan members were as likely to result in harm as in harmony. As the infant becomes a toddler and the toddler becomes a child, the brain is making a catalogue of "safe and familiar" attributes of the humans in his clan; the language, the dress, the nonverbal elements of communication, and the skin color of his family and clan become the attributes of "safe and familiar" that, in future interactions with others, will tell his stress response networks to be calm. In contrast, when this person interacts with strangers, the stress response systems activate; the more unfamiliar the attributes of this new person, the more the activation. In some cases, a clan's beliefs may have exacerbated this; if the child grows up with ethnic, racial, or religious beliefs and values that degrade or dehumanize others, the stress activation that results in an encounter with different people can be extreme. In this case, relational interactions activate and exacerbate trauma-related stress reactivity. A recent study by Chiao and colleagues (2008), for example, showed that fear-related social cues from individuals from one's own group/ethnicity have greater "power." They will induce greater amygdala activation than similar cues from individuals not in one's group. Similar group contagion of positive emotional states has been documented (e.g., Fowler & Christakis, 2008). All of this points to the powerful influence of the social milieu on individual neurobiological functioning.

The social milieu, then, becomes a major mediator of individual stress response baseline and reactivity; nonverbal signals of safety or threat from members of one's "clan" modulate one's stress response. The bottom line is that healthy relational interactions with safe and familiar individuals can buffer and heal trauma-related problems, while the ongoing process of "tribalism"—creating an "us" and "them"—is a powerful but destructive aspect of the human condition, exacerbating trauma in individuals, families, and communities attempting to heal.

The clinical implications of this understanding of the power of relational health are, again, profound. As one would predict, research suggests that social connectedness is a protective factor against many forms of child maltreatment, including physical abuse, neglect, and nonorganic failure to thrive, as well as a means of promoting prosocial behavior (Belsky et al., 2005; Caliso & Milner, 1992; Egeland, Jacobvitz, & Sroufe, 1988; Rak & Patterson, 1996; Travis & Combs-Orme, 2007; Chan, 1994; Coohey, 1996; Guadin et al., 1993; Hashima & Amato, 1994; Pascoe & Earp, 1984; Altemeier, O'Connor, Sherrod, & Vietze, 1985; Benoit, Zeanah, & Barton, 1989; Crnic, Greenberg, Robinson, & Ragozin, 1984; Gorman, Leifer, & Grossman, 1993). The number, quality, and stability of relational interactions matter to the child. Removing children from abusive homes also may remove them from their familiar and safe social network in school, church, and community. And worse, the presence of new and unfamiliar individuals can actually activate the already sensitized stress-response systems in these children, making them more symptomatic and less capable of benefiting from our efforts to comfort and heal. Our well-intended interventions often result in relational impermanence for the child: foster home to foster home, new schools, new case workers, new therapists as if these are interchangeable parts. They are not. Even "best-practice" therapeutic work is ineffective in an environment of relational instability and chronic transition.

TRANSLATIONAL NEUROSCIENCE: THE NEUROSEQUENTIAL MODEL OF THERAPEUTICS

Over the last 20 years, we have been adapting our clinical practice to incorporate emerging findings from neuroscience. This has resulted in a shift from a traditional medical model approach to a more developmentally sensitive, neurobiology-guided practice. The results are promising (see Perry, 2006; Barfield et al., 2009). A brief overview follows.

The neurosequential model of therapeutics (NMT) is not a specific therapeutic technique or intervention; it is an approach to clinical work that is informed by neuroscience (Perry, 2006). It is, in short, an effort in translational neuroscience that has been evolving over the last 15 years. The NMT process structures assessment and identification of primary problems and strengths, and it sequences the application of interventions (educational, enrichment, and therapeutic) in a way that reflects the child's specific developmental needs in a variety of key domains and is sensitive the to core principles of neurodevelopment—some of which have been articulated above. There are three central elements of the model: a developmental history, a current assessment of functioning, and a set of recommendations for intervention and enrichment that arise from the process.

NMT Developmental History

The brain organizes as a reflection of experiences both good and bad. To understand an individual, therefore, one needs to know his or her history. The NMT assessment is focused on the developmental history of the child. The NMT core assessment reviews the timing, nature, and severity of developmental challenges; these are scored, resulting in an estimate of developmental "load." This also allows an estimate of which neural networks and functions would plausibly be impacted by the child's developmental insults or history of trauma (Perry, 2001, 2006). For example, intrauterine insults such as alcohol use or perinatal caregiving disruptions (such as an impaired, inattentive primary caregiver) will predictably alter the norepinephrine, serotonin, and dopamine systems of the brainstem and diencephalon that are rapidly organizing during these times in life. These early life disruptions, in turn, will result in a cascade of regulatory functions impacting a wide distribution of other brain areas and functions that these important neural systems innervate (for more, see Perry, 2008).

A second important element of the NMT core assessment is a review of the relational history of the child during development. As discussed above, relational milieu can be protective and confer some capacity to buffer the impact of trauma, while relational instability and multiple transitions can exacerbate developmental insults. This NMT relational health history provides important insights into attachment and related resiliency or vulnerability factors that may have impacted the functional development of the child (see Figure 1).

NMT Functional Status and Brain "Mapping"

The second component of the NMT process is a review of current functioning that allows us to make estimates of which neural systems and brain areas are involved in the various neuropsychiatric symptoms. An interdisciplinary staffing is typically the method for this functional review. This process helps in the development of a working functional brain map for the individual (see Figure 2). This visual representation gives a quick impression of developmental status in various domains of functioning: A 10-year-old child, for

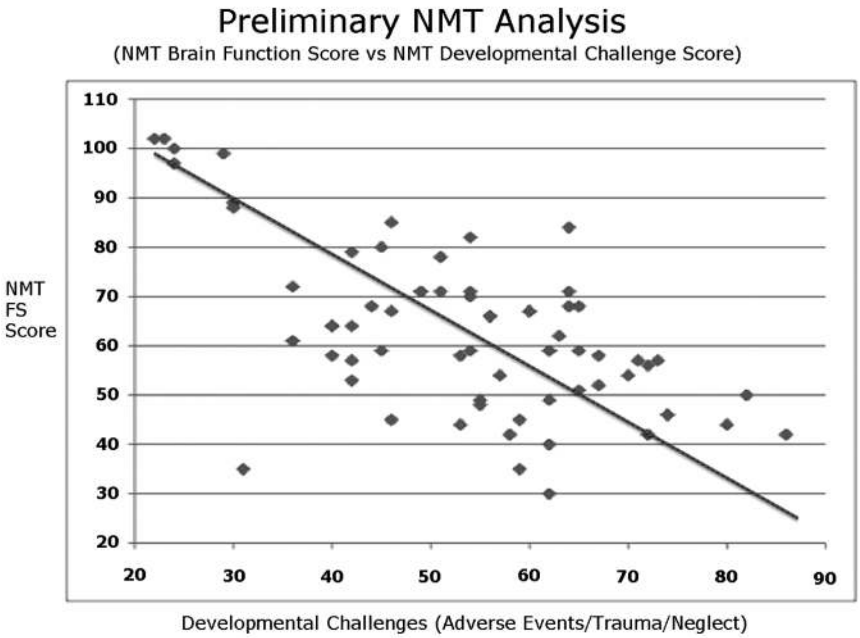

FIGURE 1 Relationship between developmental insults (trauma and neglect) and functional organization of the brain. Using the NMT developmental history measure (higher scores indicate more developmental insult such as trauma and neglect) and the NMT functional brain mapping scores (higher scores indicate positive functioning), a linear relationship is seen between number and intensity of developmental insults and the compromise in normal development and functioning of the brain. It is of interest to note that individuals who fall below the line tend to have more profound relational poverty (e.g., multiple placements, disengaged or unhealthy primary caregiving) during development, and those above the line have relatively more protective relational health (e.g., extended family, few placement disruptions, more stable family relationships). The individuals at upper left (NMT FS = approximately 90–100) are healthy comparison children. The outlying individual at lower left is a child with autism, healthy caregiving, and minimal adverse experiences during development. (Bruce D. Perry © 2008)

example, may have the speech and language capability of an 8-year-old, the social skills of a 5-year-old, and the self-regulation skills of a 2-year old. This visual "map" is very helpful when talking about trauma, brain development, and the rationale of various recommendations with educators, mental health staff, caregivers, and clients. It is also very useful to help track progress; improvement, as shown in changes in the shadings of various brain areas, is quick to see in the comparison of today's brain map with one from 6 months ago and is a powerful reinforcement for tired parents and hard-working frontline staff who feel their efforts are for naught.

This review requires a working knowledge of neural organization and functioning. In order to "localize" a set of functions to any set of brain networks or regions, the senior clinician leading the interdisciplinary NMT staffing must know child development, clinical traumatology, and developmental

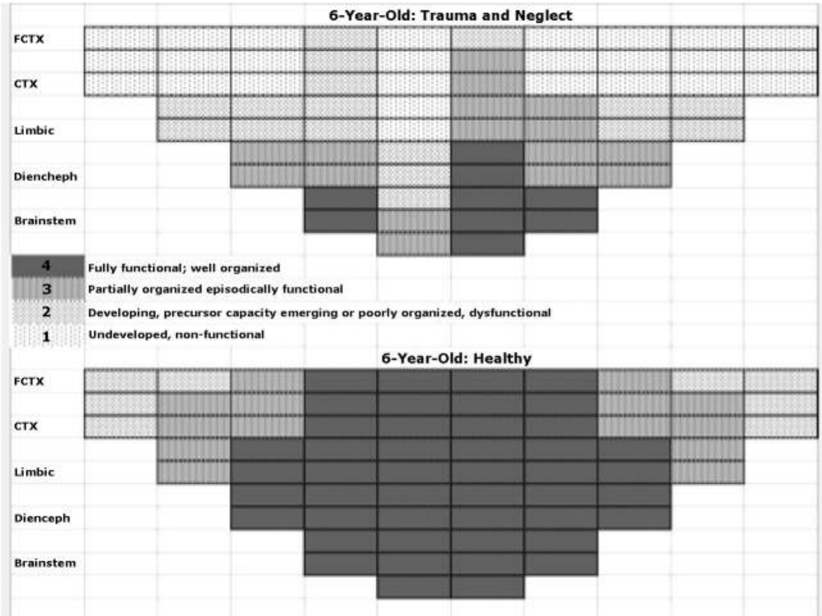

FIGURE 2 NMT functional brain "map": 6-year-old traumatized and neglected child vs. comparison child (normal development). This map is generated from an interdisciplinary staffing process examining the functional status of various brain-mediated functions. Each rectangle in the diagram indicates a brain function. Each rectangle is shaded to indicate functional status (see key above). Brain functions (e.g., regulation of heart rate: Brainstem; speech and language: CTX; attunement: Limbic) are "localized" to a brain region mediating the specific function (this oversimplification attempts to assign function to the brain region that is the final common mediator of the function with the knowledge that almost all brain functions are influenced and mediated by complex, trans-regional neural networks). This approximation allows a useful estimate of the developmental/functional status of the child's key functions, establishes the "strengths and vulnerabilities" of the child, and determines the starting point and nature of enrichment or therapeutic activities most likely to meet the child's specific needs.

neurosciences. At present, this is the major impediment in exporting the NMT approach: It requires a senior clinician to lead the process with a unique combination of clinical and preclinical skills.

NMT Interventions

The third major element of the NMT process is providing specific recommendations. The NMT "mapping" process helps determine a unique sequence of developmentally appropriate interventions and enrichments that can help the child reapproximate a more normal developmental trajectory. As outlined in brief below, these recommendations are made with various principles of neurobiology in mind; while many deficits may be present, *the sequence in which these are addressed is important.* The more the therapeutic process can replicate the normal sequential process of development, the more effective the interventions are (see Perry, 2006). Simply stated, the idea is to start with the lowest (in the brain) undeveloped/abnormally functioning set of problems and move sequentially up the brain as improvements are seen. This may involve initially focusing on a poorly organized brainstem/diencephalon and the related self-regulation, attention, arousal, and impulsivity by using any variety of patterned, repetitive somatosensory activities (which provide these brain areas with the patterned neural activation necessary for reorganization) such as music, movement, yoga (breathing), and drumming or therapeutic massage. Once there is improvement in self-regulation, the therapeutic work can move to more relational-related problems (limbic) using more traditional play or arts therapies; ultimately, once fundamental dyadic relational skills have improved, the therapeutic techniques can be more verbal and insight oriented (cortical) using any variety of cognitive-behavioral or psychodynamic approach. Further, the recommendations and enrichments are not limited to the conventional limits of "mental health" symptoms; issues in speech, learning, motor functioning, and social functioning are all addressed as part of a comprehensive, more holistic approach to the child and her or his family.

Patterned, repetitive activities shape the brain in patterned ways, while chaotic experiences create chaotic dysfunctional organization. Therapeutic activities, then, are most effective when implemented with focused repetition targeting the neural systems one wishes to modify. One cannot change a neural system without activating it; one cannot learn how to write by watching a DVD on how to write—one has to hold the pencil, make the movements, and practice and master the skill. The NMT assessment and functional mapping allow targeted therapeutic efforts in the neural systems that mediate the child's specific symptom array. When symptoms related to the persisting "fear" response (common in maltreated children) are addressed, therefore, remembering that these first arise in the brainstem and then move through the brain up to the cortex, the first step in therapeutic work is brainstem regulation. The child may also have a host of cortically mediated symptoms such as self-esteem problems, guilt, and shame. The most effective intervention process would be to first address and improve self-regulation, anxiety, and impulsivity before these cognitive problems become the focus of therapy.

A key component of the NMT recommendations relates to the child's current relational milieu. A primary finding of our clinical work (and many other researchers; see above) is that the relational environment of the child is the major mediator of therapeutic experiences. Children with relational stability and multiple positive, healthy adults invested in their lives improve; children with multiple transitions, chaotic and unpredictable family relationships, and relational poverty do not improve even when provided with the best "evidence-based" therapies. A simple metric, the NMT relational health index, scores the number and quality of relational supports capable of providing the safe, nurturing, and attuned environment in which the recommended therapeutic, educational, and enrichment activities are to be provided. In many cases, these children's caregivers or parents have similar developmental traumas, loss, or neglect; we can generate a similar "map" for the key members of the child's relational network with the goal of identifying the strengths and vulnerabilities of the adults who will be involved in helping the child. Recommendations for co-therapeutic activities where parent and child can engage and receive mutually beneficial services are common. In some cases, the specific interventions required to help the child are obvious, but the relational environment is so chaotic, and so relationally impoverished or impermanent (e.g., foster care), that the recommended interventions are impossible and the ultimate outcomes poor.

FUTURE DIRECTIONS

Awareness of key principles of neuroscience and neurodevelopment can improve practice, programs, and policy in child maltreatment. A key challenge is translating the emerging concepts into practical improvements in our clinical systems and in our therapeutic approach. A first and very important step is increasing capacity. Not enough parents, teachers, therapists, judges, or physicians know enough about child development or the basics of brain organization and function. Simply increasing awareness of the key principles of development and brain function would, over time, lead to innovations and improved outcomes; oddly enough, even though neurodevelopmental principles impact all child-related disciplines, we rarely teach the core concepts and facts of neurodevelopment to our trainees in education, social work, medicine, law, pediatrics, psychology, and psychiatry.

An additional step is to continue to develop and study the impact of interventions that begin to incorporate some of the plausible clinical implications of these principles (e.g., massage, yoga, EMDR, music and movement). While funding for research in "alternative" interventions is difficult to obtain, federal and philanthropic funders should be educated about the neurobiological plausibility of some seemingly "fringe" interventions and encouraged to fund clinical trials; if these interventions are proven to be effective, they could be included in conventional mental health reimbursement models.

While in its "infancy," we believe that the NMT, as well as other neurobiologically informed, developmentally sensitive clinical approaches, offers much promise. We continue to learn and remain hopeful that this approach will help us better understand and heal maltreated children.

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