

The Psychobiology of Maltreatment in Childhood

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The varied maladaptive behavioral, social, medical, and psychiatric outcomes associated with maltreatment in childhood have been extensively documented in the extant empirical literature. In this review, we examine the adverse impact of the stress associated with child maltreatment on the regulation of the neurobiological stress systems, alterations in brain maturation, and neuropsychological outcomes in the developing child. Further, we provide a detailed discussion of the pathway between the psychobiological consequences of trauma and subsequent cognitive, language, and academic deficits that often have a deleterious impact on global functioning. We review neuroimaging techniques and the empirical results of studies utilizing such techniques to examine brain maturation in maltreated children and individuals with posttraumatic stress disorder. We address the practice, research, and policy implications of the psychobiological sequelae of child maltreatment and offer future directions for research.

Child maltreatment (i.e., emotional abuse, physical abuse, sexual abuse, emotional neglect, physical neglect) has long been identified as a significant public health crisis of epidemic proportions and poses a significant risk for psychological difficulties to millions of children annually (American Psychological Association, 2002). In 2003, approximately 3.4 million referrals were made to Child Protective Services (CPS) agencies throughout the United States for suspicions of child abuse and neglect (U. S. Department of Health & Human Services, 2005). Many of these referrals were not investigated; however, of the two-thirds that were investigated, an estimated 906,000 children were determined to be victims of child abuse or

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neglect (19% were physically abused, 10% sexually abused, 60% neglected, 5% psychologically maltreated).

Although some children are quite resilient in the face of maltreatment, many suffer negative consequences. Such negative consequences have been documented extensively (see reviews by Arellano, 1996; Browne & Finkelhor, 1986; Malinosky-Rummell & Hansen, 1993; Read, 1997) and affect some individuals well into adulthood. In studies of children and adolescents with maltreatment histories, rates of posttraumatic stress disorder (PTSD), depression, personality disorders, conduct problems, oppositionality, attentional difficulties, suicidality, aggression, socioemotional difficulties, and substance abuse are elevated (Mulvihill, 2005). Further, adults with histories of child maltreatment demonstrate increased health risk behaviors, serious medical illnesses (Felitti et al., 1998), and psychiatric difficulties (Edwards, Holden, Felitti, & Anda, 2003; Horwitz, Widom, McLaughlin, & White, 2001; Walker et al., 1999; Widom, 1999). Thus, maltreatment can have an overwhelming impact on the developing child. In examinations of child maltreatment, therefore, one must consider the interactions between psychosocial, genetic, risk and resiliency factors, and their concomitant impact on the regulation of biological stress systems, alterations in brain maturation, and maladaptive long-term outcomes. In this article, we will review the psychobiological pathway from child maltreatment to adverse neurostructural and neuropsychological outcomes in children. In our discussion of empirical and neuroimaging findings, we will provide evidence for the biological underpinnings that mediate the maladaptive psychiatric, behavioral, and neurodevelopmental outcomes experienced by children with histories of maltreatment. Further, we will discuss the social and policy implications of the psychobiological consequences of maltreatment. Our discussion will highlight the importance of evidence-based treatments and confirm the urgent need for early intervention, widespread prevention efforts, and the provision of school-based resources for children with histories of maltreatment.

The Psychobiological Pathway: Neurobiological Stress Response Systems and Neurodevelopment

Childhood and adolescence are developmental periods characterized by marked activity in the brain, albeit most of the activity (e.g., synaptic reorganization, myelin deposition, and neuronal cell death) occurs perinatally and in early childhood. By the time a child is 2-year-old, the total brain weight is 75% of the adult brain weight, with linear increases occurring until the child is approximately 10-year-old (Giedd et al., 1999; Pfefferbaum et al., 1994; Spreen, Risser, & Edgell, 1995). During this period, selective elimination or “pruning” of neurons (Sowell, Trauner, Gamst, & Jernigan, 2002) and myelination of brain structures (Paus et al., 2001) occurs. These changes, however, occur at different times in different parts of the brain, such that regional and temporal differences have been observed

(Sowell, Trauner, Gamst, & Jernigan, 2002). In general, the maturation of the brain appears to proceed from inferior to superior and from posterior to anterior structures (Huttenlocher, 1979; Huttenlocher & de Courten, 1987; Yakovlev & Lecours, 1967), with maturation in superior parietal and frontal cortical regions being most prominent between 7 and 16 years of age (Sowell et al., 1999). Hence, any brain trauma during this period has the potential to disrupt typical neurodevelopmental processes and contribute to long-term negative consequences. Prolonged stress or prolonged exposure to glucocorticoids (i.e., the adrenal steroids secreted during stress) and elevated levels of catecholamines that result from dysregulated stress response systems during this period is likely to affect brain development adversely. Indeed, the stress of child maltreatment has been associated with alterations in the neurobiological systems that are highly involved in brain maturation, cognitive development, and emotional/behavioral regulation (De Bellis, 2005).

Three major neurobiological stress response systems [i.e., the sympathetic nervous system (SNS), the serotonin system, and the limbic–hypothalamic–pituitary–adrenal (LHPA) axis] significantly influence arousal, stress reactions, physical and cognitive development, emotional regulation, and brain development. Under conditions of chronic stress, the immune system also may be affected. The neurobiological stress systems are interconnected at many levels, such that dysregulation in one system can lead to problems in others.

The dysregulation of the neurobiological stress systems is thought to lead to the symptoms of PTSD, a psychiatric diagnosis often seen in children with histories of maltreatment. A diagnosis of PTSD indicates that a person has been exposed to a significant threat to life or bodily integrity to which they reacted with feelings of fear, helplessness, or horror (Frances, 1995). The three main clusters of PTSD symptoms include re-experiencing of the trauma, avoidance, and hyperarousal. In studies of the general population, 15–43% of girls and 14–43% of boys have experienced a traumatic event. Among those with trauma histories, 3–15% of girls and 1–6% of boys meet criteria for a diagnosis of PTSD. Among clinical and at-risk samples of children and adolescents, the prevalence of PTSD ranges from 3% to 100% (U.S. Department of Veterans Affairs). In incidence and prevalence studies cited by Perry (1999) in the Child Trauma Academy, 93% of a sample of children who had witnessed domestic violence were diagnosed with PTSD; 34% of a sample of children with a history of sexual or physical abuse, and 58% of children with a history of physical and sexual abuse demonstrated symptoms consistent with PTSD. In the following section, we will review the empirical findings as related to the dysregulation of the neurobiological stress systems in children and adults with histories of maltreatment and posttraumatic stress.

The sympathetic nervous system (SNS). The SNS (i.e., the catecholamine system) is activated during exposure to anxiety-inducing situations in which one perceives threat (e.g., child maltreatment). The SNS promotes the release of

catecholamines, including norepinephrine (NE), serotonin, and dopamine. The catecholamines cause general physiological changes that prepare the body for physical activity (i.e., they initiate the fight-or-flight-or-freeze response). During stressful situations, the locus coeruleus, a cluster of neurons in the brain that secrete NE, is stimulated. The release of NE, in turn, activates the adrenal gland, which houses epinephrine and cortisol. Elevated levels of NE and epinephrine result in increases in heart rate, blood pressure, metabolic rate, and alertness. The locus coeruleus, the major NE center in the brain, stimulates structures of the LHPA axis, which works to contain the neural, defensive stress reactions.

De Bellis, Baum, et al. (1999) found maltreated children with PTSD to have significantly higher levels of 24-hour urinary NE and dopamine and greater concentrations of 24-hour urinary free cortisol compared to overanxious children and healthy controls. In addition, a positive relation was noted between PTSD symptoms and NE levels. Increased baseline 24-hour urinary catecholamine concentrations also have been documented in boys with current depression and histories of parental neglect (Queiroz et al., 1991) and in girls who have been sexually abused (De Bellis, Lefter, Trickett, & Putnam, 1994). Perry (1994) found that children with histories of physical and sexual abuse had increased SNS responsiveness following orthostatic challenge when compared to nonmaltreated children.

Research on the SNS in adults with past trauma histories has resulted in outcomes similar to those in children. Adult women with childhood sexual abuse-related PTSD had a sensitized SNS when compared to women with a history of sexual abuse without PTSD, as evidenced by increased physiological arousal after exposure to a stressful stimulus (Orr et al., 1998). Police academy recruits with histories of childhood trauma without PTSD also evidenced a significantly greater NE response to a laboratory stressor when compared to control participants, suggesting the sensitization of the SNS (Otte et al., 2005). In another well-controlled study by Heim et al. (2000), women with a history of childhood abuse exhibited increased pituitary–adrenal and autonomic responses to stress when compared with controls. This effect was particularly robust in women with current symptoms of depression and anxiety.

Traumatic reminders (i.e., conditioned stimuli and “perceived” threats) cause continuous reactivation of the neurobiological stress systems and alter the responsiveness of the catecholamine system, which mediates stress. This altered responsiveness can be related to many of the hyperarousal symptoms of PTSD, as well as affective lability, dysphoria, and anxiety (Perry, 1994). As neurotransmitters play a key role in brain development, the dysregulation of the catecholamine system caused by prolonged or extreme stress can impact brain maturation and neurodevelopment.

The serotonin system. Serotonin serves as a modulator of emotional and physiological functioning in the central nervous system (CNS; Lesch & Moessner, 1998). Specifically, serotonin plays a role in memory, learning, temperature

regulation, mood, sexual behavior, cardiovascular function, muscle contraction, and endocrine regulation. Serotonin also is involved in behaviors like eating, sleeping, and aggression. Exposure to traumatic events leads to an increase in the release of serotonin, but the increased activity of the serotonin system likely causes long-term downregulation of serotonin production. Dysregulation of the serotonin system is thought to play a role in PTSD symptom development and increases the risk for comorbid major depression, suicidality, and aggression. In a study to investigate the activity of serotonin systems in children with and without a history of abuse, Kaufman et al. (1998) administered the serotonin precursor L-5-hydroxytryptophan, also known as a serotonin challenge (i.e., stimulation or depletion of serotonin levels), to 10 children with histories of depression and maltreatment, 10 children with histories of depression, and 10 healthy controls. Although there were no differences at baseline in response to the serotonin challenge, the children with histories of abuse and depression had significantly higher levels of the serotonin-dependent hormone, prolactin, compared to children in the other two groups, thereby suggesting that the presence of maltreatment leads to an even less-efficient serotonin system than is observed in patients with depression alone. The inefficiency of the serotonin system, in turn, may lead to cognitive deficits (i.e., learning and memory) and negatively impact behavioral functioning (i.e., aggression and mood).

The limbic-hypothalamic-pituitary-adrenal (LHPA) axis. The LHPA axis is considered the major neuroendocrine stress–response system and has been implicated in the pathophysiology of PTSD. The LHPA axis is activated simultaneously with the SNS in response to stress. The NE that is released as a result of stimulation of the locus coeruleus activates the amygdala, which is responsible for regulating emotion and anxiety. The amygdala causes the hypothalamus to release corticotropin-releasing hormone (CRH), which activates the pituitary gland and promotes the release of adrenocorticotrophic hormone (ACTH). ACTH, in turn, stimulates cortisol release from the adrenal gland. Cortisol positively reinforces the SNS system, and as stress-activated biological reactions are restricted, elevated cortisol levels suppress the further release of cortisol through negative feedback inhibition on the pituitary, hypothalamus, hippocampus, and amygdala (Chrousos & Gold, 1992; De Bellis, 2005). Studies of posttraumatic stress symptoms in individuals in the acute aftermath of a trauma have shown attenuated levels of cortisol compared to those who do not develop the disorder (Anisman, Griffiths, Matheson, Ravindran, & Merali, 2001; Delahanty, Raimonde, & Spoonster, 2000; McFarlane, Atchison, & Yehuda, 1997). Prior research does not appear to suggest that attenuated cortisol is predictive of PTSD (Yehuda, Resnick, Schmeidler, Yang, & Pitman, 1998). The attenuated cortisol response does, however, appear to be functional. Data from Resnick, Yehuda, Pitman, and Foy (1995) suggest that the attenuated cortisol response may be the result of prior traumatization.

Several investigations have focused on the effects of childhood trauma (e.g., sexual abuse, physical abuse, and other various injuries) and neglect on LHPA axis function. Collectively, these studies suggest that there is a decrease in ACTH release over time after a traumatic event; however, other events, such as environmental adversity, also play a significant role in ACTH release. Kaufman et al. (1997) administered CRH to 13 children with histories of depression and maltreatment, 13 children with histories of depression, and 13 healthy controls. Children with histories of depression and abuse living in adverse environments at the time of the study demonstrated significantly *greater* ACTH levels following the CRH challenge, as compared to children with depression and healthy controls. De Bellis et al. (1994), on the other hand, found that ACTH levels both before and following ovine CRH-stimulation were significantly *lower* in girls with past histories of sexual abuse compared to healthy controls, suggesting that the CRH receptors on the pituitary glands permanently downregulate and result in significantly lower ACTH release following CRH administration (if the children do not currently live in adverse or stress-inducing environments).

ACTH levels also have been measured in adults with histories of childhood maltreatment. When challenged with a standard laboratory psychosocial stressor, women with a history of maltreatment showed increased ACTH levels compared to women with no maltreatment history (Heim et al., 2000). Additionally, compared to control participants, adults with past maltreatment who were not experiencing major depression exhibited increased ACTH levels following CRF administration, while women with a history of maltreatment and current major depression exhibited lower levels of ACTH compared to controls (Heim, Newport, Bonsall, Miller, & Nemeroff, 2001). Adult women with histories of childhood abuse and adulthood traumas had the largest increase in ACTH following the psychosocial laboratory stressor (Heim et al., 2002). Decreased ACTH in the women with histories of depression and maltreatment may be due to the inhibitory effects of major depression on the LHPA axis. As discussed previously, traumatic experiences may sensitize the LHPA axis, resulting in overproduction of ACTH upon exposure to a novel stressor.

Numerous studies have evaluated cortisol levels in traumatized and neglected children. Interestingly, cortisol concentration appears to change as a function of time following the traumatic event. On the one hand, when cortisol levels were measured *within months* after a traumatic event, cortisol levels were significantly *greater* in traumatized individuals than in healthy controls (Carrion et al., 2002; De Bellis, Keshavan et al., 1999; Delahanty, Nugent, Christopher, & Walsh, 2005). De Bellis et al. (1994), on the other hand, measured cortisol levels in girls who experienced sexual abuse approximately *four years prior* to study enrollment and found *no significant difference* in basal and CRH-stimulated cortisol levels compared to control participants. Although the specific biological mechanism underlying this normalization of cortisol levels is not known, sexual abuse may cause chronic

hypersecretion of CRH, leading to eventual downregulation of CRH receptors on the pituitary gland and ultimately decrease the release of ACTH. Although one would expect that decreased ACTH would result in diminished cortisol levels, increased release of CRH likely sensitizes the adrenal cortices and normal cortisol release occurs even in response to diminished ACTH.

Contrary to the results of these previous studies in which elevated cortisol levels decreased over time or stayed the same, Gunnar, Morrison, Chisholm, and Schuder (2001) found that children who lived in a Romanian orphanage for at least 8 months had significantly greater average daily salivary cortisol levels than children who lived in the orphanage for 4 months or less and those who never lived in the orphanage. In the adult literature, survivors of childhood maltreatment with a clinical diagnosis of PTSD or depression demonstrated significantly higher mean cortisol levels during (Elzinga, Schmahl, Vermetten, van Dyck, & Bremner, 2003) and following (Elzinga, Schmahl, Vermetten, van Dyck, & Bremner, 2003; Heim et al., 2000) exposure to a laboratory stressor. In studies of individuals with histories of childhood trauma, the LHPA axis picture is complicated and requires further investigation. It is clear, however, that overproduction of CRH and ACTH is associated with psychiatric illnesses (i.e., depression, anxiety, sleep difficulties), as well as physical illnesses, memory loss, and difficulty concentrating (Van Gaalen, Stenzel-Poore, Holsboer, & Steckler, 2002).

The immune system. The LHPA axis and SNS have direct effects on the immune system. The anti-inflammatory effects of cortisol suppress the immune system, and increased catecholamines dysregulate cytokine production and bind to immune cells (Glaser & Kiecolt-Glaser, 2005). Through their effects on the immune system, dysregulation of the LHPA axis and the SNS places individuals at increased risk for development of infectious diseases. In a study of plasma antinuclear antibody (ANA) titers in girls with and without histories of sexual abuse, De Bellis, Burke, Trickett, and Putnam (1996) found that girls with histories of sexual abuse had twice the frequency of positive ANA titers compared to the control participants. Thus, high cortisol levels following a traumatic experience may suppress immune cells, leading to a higher incidence of positive ANA titers in sexually abused girls, and an increased potential risk for development of health problems.

Neuroimaging Findings and Brain Maturation

Neuroimaging techniques, which allow for the measurement of CNS structural changes and functional neural activity patterns, have been used for many years to study the long-term effects of trauma on the brain. More recently, imaging techniques, such as positron emission tomography (PET), magnetic resonance imaging (MRI), proton magnetic resonance spectroscopy (MRS), and functional

MRIs (fMRI) have been used. In the following section, we describe research that has used these techniques to identify differences between children with and without histories of maltreatment. We also discuss the neurodevelopmental consequences that result from these structural and functional differences.

Brain images from PET scans result from the detection of radiation from the emission of positrons, which are tiny particles emitted from a radioactive substance administered to the patient. PET scans have revealed lower levels of anterior cingulate blood flow in women with PTSD resulting from sexual abuse (Bremner et al., 1999; Shin et al., 1999). Studies in women with PTSD related to sexual or physical abuse have documented medial prefrontal cortex and anterior cingulate disruption (Bremner, 1999; Bremner et al., 2001; Shin et al., 1999) as well as decreased hippocampal volume (Bremner et al., 2001; Bremner et al., 1997; Stein, Koverola, Hanna, Torchia, & McClarty, 1997) when compared with controls.

The majority of studies with children who have been maltreated have used MRI scans to compare children with histories of maltreatment to healthy children. The MRI is an imaging technique that is a safe, noninvasive method of comparing gray and white matter brain structures—radio frequency waves and a strong magnetic field are used to provide the pictures. Studies using MRIs have documented a smaller midsagittal area of the corpus callosum in maltreated children. In one of the first of these studies, Teicher et al. (1997) found that the middle portion of the corpus callosum was reduced in children with a history of maltreatment when compared with psychiatric controls, with a more extreme effect documented in boys. Teicher et al. also documented a trend (for smaller total brain volume in boys when compared with girls). De Bellis, Keshavan, et al. (1999) found similar results in PTSD-diagnosed children and adolescents when compared with controls: The children with PTSD had decreases in the total midsagittal area of the corpus callosum, enlarged right, left, and total lateral ventricles, and a decrease in intracranial volume by 7% and total brain volume by 8%. As in the study by Teicher et al., De Bellis, Keshavan et al. (1999) also found a gender-dependent effect for the size of the corpus callosum, with PTSD boys having significantly smaller measurements of the corpus callosum than PTSD girls.

In a study of 28 children and adolescents with maltreatment-related PTSD, the intracranial, cerebral cortex, prefrontal cortex, prefrontal cortical white matter, and right temporal lobe volumes were decreased in comparison to sociodemographically matched controls (De Bellis et al., 2002). Specifically, the children with maltreatment-related PTSD had smaller areas in the corpus callosum and larger frontal lobe cerebrospinal volumes than controls (De Bellis & Keshavan, 2003). A gender-related effect was found in that boys with PTSD had larger ventricular volumes than maltreated girls with PTSD, suggesting that boys may be more vulnerable to the effects of maltreatment-related PTSD (De Bellis & Keshavan, 2003).

In the study of De Bellis et al. (1999), earlier onset of abuse and longer duration of abuse correlated with smaller intracranial volume, suggesting that brain development in these individuals may have been disrupted and that adverse effects may be greater with exposure to trauma in early childhood. Thus, recurrent and chronic abuse may have a cumulative, harmful effect on brain development. Carrion et al. (2001) found similar results, as children with PTSD or subthreshold PTSD had smaller total brain and cerebral volumes than healthy controls. In addition, attenuation of frontal lobe asymmetry was observed for the children with maltreatment-related PTSD. Unlike in the studies of adult PTSD, decreases in hippocampal volume have not been documented in children. Results from brain imaging research, however, have provided evidence for prefrontal abnormalities in maltreated children with PTSD. Children with maltreatment-related PTSD do not show the normal age-related increases in the size of the corpus callosum, suggesting that myelination in this region was not optimal due to the early exposure to stress or stress-related hormones. The interactions of gender and PTSD group that were demonstrated in much of the neuroimaging research on children with maltreatment histories and PTSD suggest that boys may be more at-risk for adverse brain maturation than girls (De Bellis & Keshavan, 2003). In a recent study, hippocampal white-matter volume was found to be greater in maltreated children with PTSD (Tupler & De Bellis, 2006). The decrease in hippocampal volume that is observed in adults with PTSD, but not children, may be an artifact of increased alcohol and substance abuse and dependence among adults and adolescents (De Bellis, Clark et al., 2000). In addition, decreases in the size of the hippocampus in children may not be evident during imaging procedures at this early developmental time point, as it may be an inherent vulnerability for chronic PTSD that persists into adulthood (Gilbertson et al., 2002). Finally, the discrepancies of hippocampal volumes seen in children and adults may be related to neurogenesis. Events in the child's life post-abuse such as disclosure, separation from the perpetrator, and therapeutic interventions may enhance hippocampal neurogenesis and mask any differences that would have been present otherwise.

Neurodevelopmental Consequences of Maltreatment

As the previously reviewed empirical findings and neuroimaging data suggest, chronic exposure to maltreatment leads to the dysregulation of the biological stress systems that are directly associated with alterations in brain maturation. The neurostructural anomalies linked to prolonged exposure to stressors, such as maltreatment, also impair neuropsychological functioning. More specifically, the accelerated loss or metabolism of neurons in the hippocampus has a direct effect on memory, learning, and the storing and processing of spatial information (Edwards, Harkins, Wright, & Menn, 1990; Sapolsky, 2000; Simantov et al., 1996; Smythies, 1997). Delays in myelination inhibit the successful development of

cognitive, motor, and sensory functions, and impede the ability to integrate information (Dunlop, Archer, Quinlivan, Beazley, & Newnham, 1997). Abnormalities in developmentally appropriate synaptic pruning hinder the adaptability of the brain and decrease its efficiency (Lauder, 1988; Sapolsky, 1996; Todd, 1992). The impaired neurogenesis in the dentate gyrus can be associated with deficits in memory, learning, and spatial organization (Gould, Beylin, Tanapat, Reeves, & Shors, 1999; Gould, McEwen, Tanapat, Galea, & Fuchs, 1997; Gould, Tanapat, & Cameron, 1997; Gould, Tanapat, McEwen, Flugge, & Fuchs, 1998; Reagen & McEwen, 1997; Tanapat, Galea, & Gould, 1998). Chronic stress also leads to decreases in brain-derived neurotrophic factor expression that may negatively impact learning, memory, and executive functioning (Smith, Makino, Kvetnansky, & Post, 1995). Further, elevated levels of glucocorticoids damage the hippocampus, resulting in learning and concentration impairments (Sapolsky, Uno, Rebert, & Finch, 1990).

A growing body of literature provides evidence that a vast array of neuropsychological difficulties, likely associated with alterations in brain maturation and the result of smaller intracranial and cerebral volumes, is experienced by maltreated children. Much of the child maltreatment outcome research examines heterogeneous groups of maltreated children (i.e., children who have experienced various forms of maltreatment). Research indicates that children who have experienced maltreatment, be it sexual abuse, physical abuse, child neglect, or psychological abuse, demonstrate a range of maladaptive outcomes including psychological distress, behavioral difficulties, and social problems, in comparison to sociodemographically matched groups of nonabused peers (Prasad, Kramer, & Ewing-Cobbs, 2005). Specifically, children with histories of abuse and neglect evidence deficits on standardized measures of cognitive and academic abilities, receive poor teacher assessments of school performance, evidence academic maladjustment, have lower grades, and more grade repetitions (Hoffman-Plotkin & Twentyman, 1984; Kendall-Tackett & Eckenrode, 1996; Shonk & Cicchetti, 2001; Veltman & Browne, 2001; Wodarski, Kurtz, Gaudin, & Howing, 1990; Zolotor et al., 1999). A negative correlation has also been documented between exposure to domestic violence and cognitive abilities and school performance (Huth-Bocks, Levendosky, & Semel, 2001; Kolbo, Blakely, & Engleman, 1996; Koenen, Moffitt, Caspi, Taylor, & Purcell, 2003).

In one of very few studies using a comprehensive battery of neuropsychological instruments to examine cognitive functioning among children with PTSD secondary to child maltreatment, Beers and De Bellis (2002) found that children with maltreatment-related PTSD performed more poorly than a matched comparison group in the domains of attention, problem solving, abstract reasoning/executive functioning, learning and memory, and visual-spatial functioning. In an examination of the long-term outcomes of physical abuse and neglect, Perez and Widom (1994) utilized a cohort design study in which 413 maltreated children and 286

matched controls were followed prospectively throughout childhood, adolescence, and into early adulthood. As young adults, the participants with a history of maltreatment demonstrated IQ and reading ability scores that were well below average when compared to established norms and members of the comparison group. When controlling for sociodemographic variables, physical abuse and neglect were found to be significant predictors of cognitive ability, while neglect was found to be a significant predictor of academic achievement.

Clinical and community samples of children with maltreatment histories have resulted in findings consistent with those noted in the aforementioned studies. In Pugh et al.'s (1997) assessment of a clinical sample of 246 abused and neglected children (*M* age = 6.94 years), IQ scores were 10 points below average, based on established norms. Eckenrode, Laird, and Doris (1993) recruited a community sample of 420 children with histories of maltreatment and a comparison group of 420 matched nonmaltreated children and found that children with histories of maltreatment were more than twice as likely to repeat a grade and scored significantly lower in the areas of reading and math as measured by the Iowa Test of Basic Skills and as reflected in their classroom grades. The children with histories of neglect had the greatest cognitive impairments overall. Similar results were obtained by Rogeness, Amrungi, Macedo, Harris, and Fisher (1985) in their clinical sample of 539 children: boys with a history of neglect had lower IQ scores than boys with a history of abuse while girls with a history of abuse and neglect had lower IQ scores than the comparison group.

In examining specific types of abuse, children with a history of neglect also have been found to be at high risk for difficulties in language production, articulation, language comprehension, and school readiness (Aber, Allen, Carlson, & Cicchetti, 1989; Allen & Oliver, 1982; Culp et al., 1991; Fox, Long, & Langlois, 1988; Strathearn, Garry, O'Callaghan, & Wood, 2001).

Research that has teased apart the effects of physical abuse and other forms of maltreatment has suggested that children with histories of physical abuse have deficits in verbal and memory skills (Friedrich, Einbender, & Luecke, 1983). Prasad, Kramer, & Ewing-Cobbs et al. (2005) also found that preschoolers with physical abuse who did not have a history of head trauma tended to perform significantly lower than a matched comparison group on measures of general cognitive ability, motor skills, and expressive and receptive language. In adolescents with physical abuse histories, lower standardized test scores and lower grades in Language Arts (Lansford et al., 2002) as well as inhibition in the use of self-related language, lesser use of syntax, and greater self-repetitions (McFadyen & Kitson, 1996) have been documented. Carrey, Butter, Persinger, & Bialik (1995) found that children between 7 and 13 years of age who had been physically and/or sexually abused (*N* = 18) had lower Verbal and Full Scale IQ scores than children without a history of abuse. In addition, a negative correlation between abuse severity and Verbal and Full Scale IQ scores was noted.

Research on girls who have been sexually abused has revealed a relation between abuse and cognitive skills and abilities, with lower cognitive abilities and academic achievement documented in a number of studies (Einbender & Friedrich, 1989; Sadeh, Hayden, McGuire, Sachs, & Civita, 1993). In their sample of 83 sexually abused children and 64 nonabused children, Trickett, McBride-Chang, and Putnam (1994) found sexual abuse to be negatively related to cognitive abilities. Bremner, Vermetten, Afzal, and Vythilingam (2004) found that women with PTSD secondary to childhood sexual abuse evidenced lower scores on tasks of verbal declarative memory than women with histories of childhood sexual abuse without PTSD and nonabused women. No significant differences were noted, however, in the areas of visual memory or overall cognitive functioning. Himelein (1995) also found no significant differences between sexually abused and nonabused college women on indicators of academic adjustment (i.e., grade point average, credit hours earned, probability of remaining in college). Research with adults with abuse histories (i.e., sexual abuse) suggest that the deficits identified in children with maltreatment histories may persist into adulthood.

Implications for Practice, Research, and Policy

The empirical findings discussed herein suggest that the overwhelming stress of childhood maltreatment is associated with alterations of the biological stress systems, which, in turn, leads to adverse effects on brain development and delays in cognitive, language, and academic skills. It cannot be definitively determined, however, that the alterations in the biological stress systems and the subsequent effects on brain maturation account for the psychological problems and cognitive deficits frequently experienced by children who have been maltreated. There are a multitude of risk factors associated with child maltreatment, which also might affect these outcomes. PTSD in children who have been maltreated may be regarded as an “environmentally induced complex developmental disorder” (De Bellis, 2001). In addition, children from maltreating families may be at a genetic risk for cognitive impairment (Koenen, Moffitt, Caspi, Taylor, & Purcell, 2003).

Fortunately, not all children who are maltreated are adversely affected. In fact, many children have good outcomes despite high risk and stressful circumstances. Evidence suggests that the negative effects of stress on the CNS may be reversible (Gould et al., 1998, 1999). Environmental stress appears to play a large role in this process (Tanapat, Galea, & Gould, 1998). Hence, early detection of child maltreatment is vital. Public health professionals, educators, and medical personnel working with children and families should participate in professional development activities that will facilitate their ability to detect signs of maltreatment, and these professionals should be informed of the appropriate child maltreatment reporting procedures in their state. Child protective services agencies are encouraged to act expeditiously in the removal of a child from an adverse environment, as the

prolonged stress on the child may have a significant effect on their neurostructural development, neuropsychological, psychiatric, and behavioral functioning.

Public policy should be developed to advance and disseminate empirical findings in regard to the deleterious effect of child maltreatment on the developing child. In particular, prevention programs should be targeted at identifying families at-risk for maltreatment and providing the evidence-based services and resources for these families. Due to the educational needs of children with histories of maltreatment and significant trauma, school systems should be encouraged to act more aggressively to identify these children and to provide them with the appropriate neuropsychological assessments to determine if any specific deficits exist, as well as to develop a profile of individual strengths and weaknesses. Additionally, schools should provide remediation and supplemental services for maltreated children specific to the cognitive impairments they may be experiencing.

The findings reviewed herein also highlight the need for effective treatment after exposure to traumatic events such as child maltreatment. Trauma-focused cognitive-behavioral treatment (TF-CBT) has shown significant promise in the treatment of children who have been traumatized (see reviews by Pine & Cohen, 2002, and Cohen, Mannarino, & Rogal, 2001). One important component of this treatment is the incorporation of the child and the nonoffending parent, particularly because research has demonstrated that environmental consistency after a traumatic event affects behavior and neuroendocrine activity (Fisher, Gunnar, Chamberlain, & Reid, 2000). Treatment of trauma-related symptoms with evidence-based psychotherapy, and if needed, medication management, theoretically can improve global brain function by removing the stress-mediated inhibition on the rate of cortical neurogenesis (De Bellis & Thomas 2003).

Collectively, these data suggest that the effects of PTSD and child maltreatment are preventable contributors to child psychopathology, cognitive impairment, and developmental difficulties. Basic scientists, clinical and policy researchers, and mental health treatment professionals should be working tirelessly in joint efforts to prevent the negative outcomes associated with such events. Unfortunately, however, clinical prevention and intervention research for maltreated children and their families is markedly underfunded.

Future Directions

Future research on childhood maltreatment and the associated adverse neurostructural and neuropsychological outcomes should incorporate longitudinal studies that can better identify the pathway from trauma exposure to abnormalities of brain structure and function, including proposed critical periods of vulnerability and resilience. Methodologically, research could be improved by incorporating observational and interview data, as well as the reports of multiple informants across varied domains of child functioning. The use of more comprehensive

neuropsychological batteries will be instrumental in further elucidating the cognitive deficits experienced by children with trauma histories. In addition, it will be important to evaluate the influences of the multiple mediating and moderating variables, including biological, genetic, environmental, individual, and situational factors. The delineation of factors that potentiate outcomes for each of the maltreatment subtypes also is necessary, particularly in the development of preventive interventions. To understand brain structure and function, studies also should include neuroendocrine evaluations as well as functional neuroimaging techniques while stress is induced in the laboratory. If neurogenesis does, in fact, occur in children, psychotherapeutic and psychopharmacological interventions may attenuate the changes that are otherwise observed as a result of maltreatment. Neuroimaging research also is needed to determine whether treatment (either therapy or medication) has an effect on brain structure and function and to better understand the mechanism of the effect of psychotherapy and medications in children with histories of maltreatment.

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